

JEFF THOMPSON RESEARCH AWARD REPORT

The changing face of teaching and learning: An empirical study to explore the impact of technology-enhanced learning on pedagogy, assessment and learning environments in International Baccalaureate Diploma Programme schools.

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December 2022

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Abstract

Digital technology has emerged as one of the most important topics concerning learning in present times. The rapid pace of technological development has led to a transformation in teaching, learning and assessment. This transformation is driven by the quest to develop new ways of learning and augment the classroom environment by including new technologies and methods. The recent global pandemic has accelerated the transformation in school settings worldwide, with school closures that began in early 2020 causing severe disruption to teaching and led to a major shift in the online learning environment.

The research in this thesis was conducted during the challenging period of COVID-19, while schools across the globe were experiencing a major shift to remote and hybrid models of teaching and learning. The research set out to capture the significant impact of Technology Enhanced Learning on pedagogy, assessment and learning environments in the context of the International Baccalaureate (IB) Diploma Programme (DP). It was carried out in two stages. Study A explored IBDP teachers' and coordinators' views on the transitioning experiences caused by the shift to online learning during the pandemic. The participants in this study were 80 IB Diploma Programme (DP) teachers, coordinators, and administrators. Study B was a case study of one international school that explored the role of Artificial Intelligence (AI) in teaching and learning of mathematics in an international (IB) school. There were in total 6 students who participated in this study, 3 core level mathematics students from grade 9, 3 higher-level mathematics students from grade 11- IB Diploma Programme and a mathematics teacher. Data in the studies were collected through questionnaires, and through teacher and student interviews.

The outcomes of this research offer an understanding of key issues concerning the implementation of digital technology in several aspects of pedagogy, assessment and learning environments in IB Diploma Programme schools. Key findings emerging from Study A elucidate issues concerning the transition to online teaching that includes access to adequate digital infrastructure and digital resources, as well as challenges in effective curriculum delivery: specifically, differentiation, autonomous learning, student engagement, student motivation, group work and the designing of online assessments. Key findings from Study B include that the implementation of Artificial Intelligence in teaching and learning offered personalised learning support that included an individual learning path, additional practice, and revision assistance, and improved the learning experience through scaffolding support, and strengthening of foundational skills. It supported self-paced and self-directed learning approaches that enhanced student motivation and engagement.

Drawing on insights derived from published literature as well as on findings from the data collected in this study, the research concludes by proposing strategies for consideration by IBDP leaders and teachers in the design and development of approaches for the application of emerging digital technologies in teaching and learning. Outcomes of this research address the implications of emerging digital technologies for shaping future school learning environments that may be explored in terms of possible transferability to other contexts in future research.

1. Introduction

The rapid pace of technological advancement in the last two decades has added another dimension to the educational change as society became interconnected through the internet and social media platforms. Over the years different terms like educational technology, instructional technology, information, and communication technology (ICT) for learning, computer-assisted instruction, educational computing, and many more have been used to describe the use of digital technology in teaching and learning (Chan et.al., 2006). Another such term is Technology Enhanced Learning (TEL) which refers to a range of technologies utilised in the learning settings. Digital technology in teaching and learning includes the use of electronic tools, systems, devices, and resources that generate, store or process data.

The idea of integration of new digital technologies has often been associated with educational change, based on an aim to reform and positively influence teaching and learning (Cuban, 2001; Lei & Zhao, 2008). New digital technologies have expanded across school settings though the pace of adoption in the classroom has been quite slow (Selwyn & Facer, 2014). The pace of adoption of new technologies and the dilemmas to integrate them into mainstream teaching necessitates a radical shift from the traditional ways and a new pedagogical vision based on digital skills and literacies in school settings (Livingstone, 2012).

On the other hand, learners across the world have become increasingly reliant on social networking technologies to connect, collaborate, and create new learning experiences which stressed the need for the learning environments to undergo a change and integrate new technologies in teaching and learning. The last decade has witnessed an escalated trend in the amount of published data both on the organisational and personal front. This includes large organisational data sets to provide performance indicators and access to personal data through different social networking sites. The term 'data economy' is often used to describe the commercial use of large data sets to analyse and offer more personalised support customised to the individual users. This trend also carried innumerable opportunities and promises to improvise, measure, and evaluate the learning processes in educational settings (Retalis et al., 2006; Johnson et al., 2011). The term Learning Analytics in educational settings is used to monitor and assess students' progress, predict future performance, and identify potential problem areas in learning using student performance data (Johnson et al., 2011).

This application of Learning Analytics has grown rapidly in educational settings in the last decade, a notable example in this area is the focus on research in personalising learning environments (Manouselis et al., 2010) to improve the quality and efficiency of the learning processes. Thus, the expeditious growth of digital technology calls for profound changes in the way education is viewed, to examine the trends that influence the demands of work and life, new emerging skills, and the potential of human resources to meet the challenges of living and working in the present times.

My interest in this topic stems from my varied experiences with the IB schools. As an IB Diploma Programme teacher, Coordinator and later as Head of Senior School, I have been fascinated by the transformative role of Technology Enhanced Learning (TEL) in supporting pedagogy and formative assessment practices in the classroom. And ways it can further evolve to support the autonomous and personalised learning opportunities for students. Furthermore, I have actively supported IB's development as a DP consultant, workshop leader, and school site visitor. In these roles, whilst interacting with the DP teachers in several settings, I identified common issues and patterns related to pedagogy and assessment that emerged across different contexts. I found that some of the areas where teachers struggled to evidence their practice were around differentiation, autonomous learning, formative assessments, individualised support to students. Additionally, during these interactions and

visits to different schools, I observed that integration of technology to aid teaching and learning in the IBDP is an area that was not put to optimum use, it was either neglected or obstructed due to contextual challenges. This further piqued my interest and provided me with ideas to explore it as a part of my doctoral research.

The global pandemic has accelerated the process of digital change in school settings across the globe. The school closure due to the pandemic in early 2020, caused severe disruption in teaching and led to a major shift to the remote learning environment. UNESCO's figures for learners enrolled at pre-primary, primary, lower-secondary, and upper-secondary levels of education as well as at the tertiary level. It is estimated that 80 per cent of the world's learners were kept out of educational institutions by country-wide closures (World Economic Forum Report, 2020). The highlight of this disruption was a major crisis and unexpected shift experienced by educational settings (UNESCO, 2020a). This sudden shift from face-to-face classroom-based teaching to remote learning and the use of digital technology significantly impacted students, teachers, and the learning process in school settings (Patel et al., 2020).

This study aimed to investigate the existing issues and challenges of the effects of digital technology on pedagogy, assessments and learning environments in International Baccalaureate (IB) schools during the pandemic. The study was developed in two stages- Study A includes a research project to analyse the views and experiences of IBDP teachers and coordinators on the impact of digital technology in the design and delivery of online teaching during the COVID-19. In the second stage Study, B includes a case study conducted at an international school in the UK, to investigate the potential role of Artificial Intelligence (AI) in teaching and learning through the implementation of an AI application in mathematics at the secondary school level.

This research makes an argument for the significant role and innumerable opportunities offered by the new digital technologies to develop personalised and autonomous learning approaches. By exploring the perspectives of teachers, administrators, and students in IB schools, this study provides a critical discussion point on the role of new digital technologies in teaching and learning.

1.1. Aims & Objectives

Aims

Study A aims to explore the impact of Technology Enhanced Learning (TEL) on pedagogy, assessment and learning environments in IBDP schools. Study B further explores the potential role and benefits of Artificial Intelligence (AI) in personalising learning experiences for students. The following objectives led to the development of this research.

Objectives

1. To understand the transitioning experiences of teachers to online teaching during school closure due to the global pandemic.
2. To understand issues in technology-led curriculum and pedagogy in the IBDP.
3. To understand the benefits and challenges of conducting digital assessments for the IBDP.
4. To identify issues in implementing personalised learning approaches during the online teaching phase while schools were closed due to the global pandemic.

5. To understand the factors that support autonomous learning in a technology-enhanced learning environment in the IBDP.
6. To develop strategies for integrating emerging technologies (such as Learning analytics and AI) into teaching and learning in the IBDP curriculum framework.

The above aims and objectives led to the development of the following research questions which have been investigated during this research.

1.2. Research Questions

RQ1: In what ways does technology-enhanced learning influence pedagogy and assessments in International Baccalaureate schools?

RO1.1. To understand the transitioning experiences of teachers to online teaching during school closure due to the global pandemic.

RO1.2. To understand issues in technology-led curriculum and pedagogy in the IBDP.

RO1.3. To understand the benefits and challenges of conducting digital assessments for the IBDP.

RQ2: How far does technology-enhanced learning offers independent and personalised learning opportunities to students?

RO 2.1. To identify issues in implementing personalised learning approaches during the online teaching phase while schools were closed due to the global pandemic.

RO 2.2. To understand the factors that support autonomous learning in a technology-enhanced learning environment in the IBDP.

RQ3 What are the implications of the emerging technologies for shaping the learning environments in International Baccalaureate schools in future?

RO 3.1. To develop strategies for integrating emerging technologies (such as AI) into teaching and learning in the IBDP curriculum framework.

2. Literature Review

At the outset of the literature review, I built on the ideas and materials from my initial research proposal and then moved to more definite scoping and mapping activities, identifying different bodies of literature to inform the context of the study, its theoretical underpinnings and to develop the research questions. I investigated literature regarding the role of TEL in the context of pedagogical developments, technology integration to reform assessment practices, educational data mining and the role of learning analytics. Furthermore, I explored recent publications on the role of AI in education and ways it can be used in personalising learning environments. Since AI in education is an emerging field, I have continued to review the publications and current studies to keep myself updated with the developments in this burgeoning area. I chose a thematic literature review using the material referred to during the research proposal stages and moved to the author, topic, and keyword searches, along with citation and reference checking. After the completion of fieldwork, I used an iterative approach to identify literature for further developing my ideas and argument while working with the data to produce a more nuanced picture.

To provide a conceptual lens for my research, I explored the epistemological framework underpinning Lev Vygotsky's theory of Zone of Proximal Development. I also compiled a list of key journals on Educational Technology and AI in education to facilitate the inquiry into the key concepts and the development of the research questions. Some of the key journals while doing the topic and keywords search during the review is the British Journal of Educational Technology (BERA), Educational Technology and Society, Journal of Research in International Education (JRIE), International Journal of Artificial Intelligence in Education, SOLAR-Society for learning analytics, Journal of Learning Analytics and Journal for Educational Change. I also referred to the reports from some of the key organisations like the World Economic Forum, Organization for Economic Cooperation and Development (OECD), National Endowment for Science, Technology, and the Arts (NESTA), publications from University College London (UCL) Knowledge lab, UNESCO, Joint Research Centre (JRC) and the IB publications.

The literature was examined and organised under three broad themes and have been presented below.

2.1. Technology Enhanced Learning and Teaching (TEL)

Though there is no universally agreed definition of TEL several experts have attempted to define it. Kirkwood and Price (2014, p.7) described "it is rare to find explicit statements about what TEL means. Most frequently, TEL is considered synonymous with equipment and infrastructure". While Duval, Sharples and Sutherland (2017, p.2) defined various components associated with TEL as "learning through technology; design of learning materials; individualised learning; enhancing rather than replacing human teaching." Goodyear and Retalis (2010) explained TEL as, "an attractive, broadly defined term because it includes all technologies that help make learning more effective, efficient and enjoyable." Dror (2008) further expands and states that TEL also includes the use of web-based services, emails and different software that facilitate learning. It is vital to clarify that the term, Technology-enhanced learning comprises both teaching and learning. Goodyear and Retalis (2010) recommended six different stages for incorporating technologies in teaching and learning a) for accessing and studying learning material b) for learning through inquiry c) for learning through communication and collaboration d) for learning through construction e) for learners' assessments and f) to improve digital and multimedia literacy.

TEL is the term that was used in the early 2000s in the UK and European nations as a part of the European Union policy. In 2009, a European Network of Excellence in technology-enhanced learning was established and research in this area received separate funding. Similar efforts were seen across the globe with the USA also providing a 650 million dollars grant for supporting educational technology initiatives under the Obama government.

Kirkwood and Price (2013) described the advantages of TEL in terms of qualitative and quantitative changes in learning and operational improvement. Copley (2007) and Taylor and Clark (2010) further explain that operational improvements aim to improve the learner's experience of accessing the learning resources using appropriate technology tools as opposed to conventional resources in teaching and learning. Kirkwood and Price (2013) claim that qualitative changes or improvement in learning is related to skill development that includes higher-order thinking skills, reflection, and increased interaction between students because of technology-enhanced learning. Whilst quantitative changes include improvement in learner's knowledge with technology interventions. This is measured using a pre-test and post-test score and the difference quantifies the improvement in learning (Salkind 2010).

Furthermore, the recent trends in education reflect a growing interest in the field of 'learning analytics and educational data mining' which has become a popular research area for TEL a

trend led by pedagogical, political, and technological factors (Ferguson, 2012, p.2). Therefore, the fields of learning analytics and educational data mining have emerged as two significant areas to support educational decision making by extracting relevant information from the educational data sets (Daradoumis et al., 2010a). Both these fields are focused on analysing educational data to identify hidden patterns both cognitive and behavioural and further use those patterns in making predictions for improving learning. Educational data mining is concerned with “developing, researching, and applying computerised methods to detect patterns in large collections of educational data that would otherwise be hard or impossible to analyse due to the enormous volume of data within which they exist” (Romero & Ventura, 2013, p.12). While the 1st International Conference on Learning Analytics and Knowledge defines learning analytics, as “the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and environments in which it occurs.”

Educational data mining focuses more on techniques and methodologies while learning analytics is concerned with applications. Recent trends in teaching reflect a trend of using data-driven approaches to measure and improve learning as used in business intelligence or analytics (Daradoumis, Rodríguez-Ardura, Faulin, & Martínez-López, 2010b). Many schools rely on digital data to measure and benchmark school improvement in a high-stake assessment context. This assumes that data provides an in-depth objective view of student learning in place of subjective judgments on learning (Sutherland, 2013). This assumption has attracted much debate given the underlying ethical consideration and academic integrity concerns (Facer, 2012).

To respond to the research questions, it is significant to address considerations of the pedagogical and assessment developments using technology that reveal different approaches associated with the implementation of TEL in educational contexts. Considering the role of Technology-Enhanced Teaching (TET) for pedagogical approaches, TET elucidates several theories, conceptual frameworks and models that have been adapted over time. This includes considerations related to asynchronous and synchronous learning environments. One of the popular frameworks that focus on the relationship between pedagogy, subject content and technology is the TPACK framework (Mishra, & Koehler, 2006). The TPACK framework provides significant guidelines in ways technology enables educators to use innovative pedagogical practices for delivering the content in their specific settings (Kurt, 2019). Likewise, Bergmann and Sams (2012), proposed the flipped classroom model in their book, *‘Flip your classroom: Reach every student in every class every day*. The four important elements that constitute F-L-I-P are flexible environment, learning culture, intentional content, and professional educator. Similarly, another popular model for technology integration in business and educational settings is TIM-Technology integration Matrix which recommends ways to integrate technology and continued professional development (FCIT, 2019). Also, (Gordon, 2014, p.3) in a report titled, *Flexible Pedagogies: technology-enhanced learning* focuses on, “how e-learning, also known as technology-enhanced learning, may support flexible pedagogies, and so encompasses a range of topics where technology can enable new choices for learners. Flexible learning focuses on giving students choice in the pace, place, and mode of their learning.” The report further elaborates on flexible pedagogical approaches like blended learning that makes provision for delivering computer-mediated or electronic content and support material to students with restricted requirements for real-time interactions. These approaches are gaining popularity as it offers opportunities for students to access the content at their own pace which creates a flexible learning pathway. The computer-mediated or electronic learning offers applications to manage the content released to students based on their individual progress (e.g., Wen et al., 2012).

In the context of the IB Diploma Programme, the curriculum framework identifies the important role of technology in teaching and learning. The document *Programme standards and practices* (IB 2014b) refers to schools allocating “appropriate” electronic resources to support

the teaching of the programme. Likewise, IB guideline document titled, *Diploma Programme: Principles to Practice*, outlining the Philosophy and Principles of the Diploma Programme (IB, 2009a p,13) further stresses on the use of ICT in teaching. Furthermore, the introduction to *Approaches to Teaching and Learning in the Diploma Programme* (IB, 2014c) explicitly emphasises the effective use of technology resources and provides a specific framework for skill development. The section on utilising technology effectively in the document suggests the use of resources like TPACK, TIM and SAMR (substitution, augmentation, modification, redefinition) model proposed by Puentedura (2013).

The above guidelines provide a general framework to the IBDP schools that adds subjectivity at the implementation levels in different contexts. Whilst the pace of technological change in the past decade has been phenomenal, with new technologies being introduced and adopted in education, these guidelines have remained unchanged. New digital technologies have revolutionized the various aspects of teaching and learning however, in my experience as an IB educator the pace of change to adapt to these technologies in IBDP schools have been slow except in a few schools. I would contend, in practice (except for a few schools) it continues to be a theoretical framework, which gets obstructed due to contextual challenges, lack of affordances, infrastructural and resource support, absence of initiatives and willingness amongst teachers to reinvent the classroom practices. Furthermore, these individual studies (as discussed above) analyse critical aspects concerning the integration of technology in teaching and learning and suggest improvements in education. However, none of these scholars have examined these developments or educational reforms from an overall system perspective. While these conceptual frameworks and models may serve as effective pedagogical tools, it is imperative to understand the limitations surrounding context, feasibility, reliability, and affordances at the implementation stages.

Corresponding to the pedagogical developments, there have been several efforts to integrate technology in the assessment process, especially in the last two decades. Pellegrino and Quellmalz (2010, p.130) state, 'There is an interesting and powerful confluence among theory, research, technology, and practice, especially when it comes to the integration of curriculum, instruction, and assessment'. The past decade has witnessed a significant shift in the way technology is used in the classroom. The students are using a lot of online platforms to gain knowledge and understanding of subject content. There has been a focus on "e-assessment" to integrate technology in the assessment process. There have been several efforts to integrate technology-enhanced assessment (TEA).

Some of the efforts where digital technology has been used for formative assessment are virtual environment Quest Atlantis (www.atlantisremixed.org) which employed a game-based approach, and the AsTTLE project in New Zealand (<http://e-asttle.tki.org.nz/>) which enables teachers to create online assessments and the REAP (Re-engineering Assessment Practices) which was designed to refine the feedback process and was used by the schools and higher education institutes (Oldfield et al., 2012, p.10). The REAP project was a Scottish government initiative under its e-learning transformation programme between 2005-07 and received funding from the Scottish Funding Council. It was launched as a collaborative effort between the University of Strathclyde (as the lead university), the University of Glasgow and Glasgow Caledonian University. It piloted the redesign of formative assessment and feedback practices at these three institutions. The main aim of REAP was to redesign the formative assessments to develop amongst students the ability to monitor, manage and self-direct their learning. The success of this project impacted the assessment policy and led to the adoption of an expanded set of assessment principles at the university level (Oldfield et al., 2012, p.10).

Apart from Computer-assisted and online testing, technology-enhanced assessment (TEA) has shown a strong presence in the managing and processing of result data, learning analytics to track performance progress and collaboration through peer assessment (Beevers et al.,

2011). The potential of technology-enhanced assessment is well debated and documented. (JISC, 2010; Pellegrino & Quellmalz, 2010; Winkley, 2010; Schwartz and Arena, 2009; Angus and Watson, 2009; Whitelock and Watt, 2008; Whitelock et al., 2006). However, some of the evident benefits are improved learning outcomes of students and a wide range of measurements of students' skills both knowledge and cognitive abilities with the help of data sets which was earlier difficult to achieve. It allows alternate ways of assessment that also supports learners with special educational needs (Oldfield et al., 2012).

Conversations and research recognise the kind of skills students require to enable them to acquire self-awareness as, the basis for individual target setting, the capacity to choose between different options in a complex and unpredictable environment, and creativity to be able to generate new solutions to problems and self-reliance, in short, knowing what to do when you don't know what to do' (Claxton, 2002). Therefore, the need for self-assessment and autonomous learning skills forms a central tenet of all the assessment reforms discussed and debated in the past and those have been described here briefly. A key element that emerges from these debates and profoundly impacts the learning outcomes and individual level of engagement is the ability of the individual learner to identify their patterns of strengths and weaknesses and use that knowledge to set clear and achievable targets for themselves. Self-regulated learners have learned how to set learning goals, ask good questions, self-interrogate as they learn, generate motivation and perseverance, try out different learning processes, self-monitor the effectiveness of their learning, reflect on achievement, and make changes to their learning processes where necessary (Zimmerman & Schunk, 1989; de Bruin et al., 2011; Wolters, 2011) cited in (IB, 2014c).

Technology enhanced assessment (TEA) practices (as discussed above) show that some of these issues may be addressed effectively with the integration of technology in the present learning environments. Whilst the necessity and importance of integrating technology in the assessment process has been discussed and emphasised above, I concur with the views of authors like Draper (2009a), Draper (2009b), Boud & Molloy (2013), and Hattie & Brown (2008) contend that innovations in assessment practices must be based on a 'pedagogically driven model that can allow students to take more control of their learning and become more reflective' (Whitelock and Watt, 2008, p.152), in place of considering new forms of assessment based on prospects of technological developments only.

Likewise, it is equally important to elaborate some of the challenges that are encountered by the schools at the implementation stages. Current assessment practices in schools only assess a narrow and limited range of abilities of the learners. In my experience as an IB educator, Internal Assessment tasks in the IBDP require time and commitment from students to develop the desired skills as per the criteria of the tasks. This often leads to time management issues since students are unsure of their skills and ability to attempt or select a particular task. It often goes through a trial-and-error procedure and results in a loss of time and effort. Though it has been widely acknowledged and accepted that both internal and formative assessments are building blocks in the learning process the weights assigned to these tasks are significantly low as compared to the summative (external) examinations in IBDP subjects. The internal assessment tasks in subjects carry a 20% to 25% weightage except for languages A and B where the weights range between 30% to 45%.

As an IB educator, I have observed the time management issues concerning the delayed feedback from the teachers subsequently impacts the student's completion of internal assessment tasks in the IBDP. The formative feedback mechanism in IB schools during the completion of these internal assessment tasks is hugely impacted due to teacher's workload, teacher-student ratio, a large amount of paperwork and documentation that teachers are expected to maintain for quality assurance, internal audits and to meet the accountability measures to various stakeholders. Moreover, the feedback provided to students is often not

specific, and lacks clarity and is not developmental in nature. Higgins, Hartley, and Skelton (2001, p.270) argued that “Many students are simply unable to understand feedback comments and interpret them correctly.” The aim of feedback in formative learning is twofold: a) to support the teachers in modifying their teaching strategies and b) to support the learners in self-regulating and motivating them to move forward. Oscarson (1997, p.184) observes that a “learner’s need for practice in assessing his or her performance tends to be a neglected consideration. Therefore, the importance of learner guidance, particularly at the initial stages, needs to be stressed.”

Therefore, various challenges impede the implementation of technology-enhanced assessment (TEA), associated cost and assessment design are the most challenging factors. Any large-scale successful implementation requires a cultural and organisational level change with clear pedagogic benefits. Some of the other shortcomings include a lack of staff training and adequate technical infrastructure support, concerns over validity and reliability, difficulties in scalability and transferability of practices, online security issues, cost of investment due to which implementation of technology-enhanced assessment practices has been confined to specific projects and initiatives only (Oldfield et al., 2012, p.14).

The COVID-19 pandemic provided a platform to re-examine these issues as the unprecedented changes caused an overnight shift to rely on digital technology. These aspects have been further discussed below.

2.2. Teaching & Learning during COVID-19 pandemic

The COVID-19 pandemic impacted the world in profound ways. It has not only affected the global economy but also caused the largest disruption of education systems worldwide (UNICEF, 2020). The salient feature of this disruption was an unexpected change presenting a major educational crisis experienced in the history of mankind. Approximately, 1.5 billion learners across 190 countries that have been impacted due to school and university closures. This closure of schools and other learning spaces has impacted 94 per cent of the world’s student population, up to 99 per cent in low and lower-middle-income countries (UNESCO, 2020a). It is estimated that 23.8 million additional children and youth (from pre-primary to tertiary) may drop out or not have access to school next year due to the pandemic’s economic impact, exacerbating the pre-existing gaps and inequalities in different educational settings (UNESCO, 2020a). This swift change overnight from a physical classroom to an online learning environment had a distinct impact on the use of digital technology in a school setting (Patel et al., 2020) stressing the need for teachers and students to adapt to new technology platforms for learning (Education Endowment Foundation, 2020; UNESCO, 2020c). Despite the transition challenges encountered by the educators and the learners, online learning, distance, and continuing education offered solutions during the unprecedented global pandemic (Pokhrel & Chhetri, 2020).

The sudden shift and reliance on technology platforms and learning management systems due to the pandemic led to several challenges for educators, school leaders and students. A major challenge that emerged during the research was related to access, affordability, flexibility, pedagogy, lifelong learning, and educational policy (Murgatrotd, 2020). Several countries struggled to have a reliable internet set up, and access to adequate digital devices to implement online teaching. The developing countries faced a similar issue where students from economically backward backgrounds had no access to electronic devices which severely impaired their learning (UNESCO, 2020). The data package costs were relatively high and unaffordable for parents from low-income groups (Owusu-Fordjour et al., 2020). Research further indicates several issues around an enabling home environment and lack of parental support during online teaching which resulted in increased stress and learning difficulties amongst the students (Meo et al., 2020). Thus, they not only missed a stimulating and

enriching learning environment but also opportunities, social interaction and in some cases adequate nutrition which is likely to affect their longer-term healthy development, particularly those children from poor and disadvantaged families (United Nations, 2020). Another emerging concern during this transition was the lack of capacity or willingness of the teachers to adapt to the required situation. Teachers across the globe were largely unprepared and some of them even lacked basic ICT skills to support online learning and adapt to new teaching methodologies (United Nations, 2020). This reinforces the professional development requirements of the teachers to support and equip them with new modes of education delivery (United Nations, 2020).

This shift has elucidated perennial issues about the pedagogical and assessment practices in the educational context. It has also highlighted that the current teaching approaches and existing models are losing their relevance across the globe. Research conducted during this period reflects with few exceptions, the school systems are struggling to revise the way they operate to accommodate the current trends and technologies. The published literature during this period identifies immense challenges in the design and conduct of assessments which faced several trials and errors. There was a lack of clarity and unpreparedness amongst organisations and educators to address this issue. The sudden lockdown and school closure not only impacted the internal assessment but also public examinations like the General Certificate of Secondary Education (GCSE) and International Baccalaureate. The possibility of postponement or cancellation of the entire examination depending upon the length of lockdown was indicated (United Nations, 2020). This decision has highlighted a distinct need for considering alternate ways of assessment reinforcing the focus on formative and evidence-based assessment practices as opposed to traditional ways of measuring student learning based on memorisation and set standards. Another area imposing several challenges was concerning authentic assessments and timely feedback which forms an important aspect of learning. The educators and schools found it extremely difficult to conduct formative assessments and provide timely feedback to students during online teaching (Doucet et al., 2020).

Despite tremendous challenges, the pandemic also presented innumerable opportunities for educators, students, organisations, and governments for implementing or introduce online teaching. Various technology platforms and social media tools like Google Classroom, Zoom, Messenger, WhatsApp, WeChat, and many other similar tools were used for the first time for facilitating online teaching and learning (Doucet et al., 2020). Teachers were compelled to develop new ways of teaching to overcome the barriers in the virtual environment which included extensive collaboration within the school and beyond to improve online teaching. The pandemic elucidated unparalleled opportunities to collaborate and co-create experiences using new technologies as stakeholders (Doucet et al., 2020). Research for the OECD further reported ‘an increase in the autonomy of pupils to manage their own learning’ which was an unanticipated benefit of home-school (Reimers & Schleicher, 2020b, p.18).

The significant progress made by the adaptive learning models in education in recent times makes it possible to personalise instruction and encourage self-paced and self-directed learning. It also has the potential to play a key role in addressing the educational access issues in regions where there is a paucity of qualified staff. As Anthony Seldon and Oladimeji Abidoye remarked in their book titled, *The Fourth Education Revolution, Will Artificial Intelligence Liberate or Infantilize Humanity*, The ‘Holy Grail’ would be for every student to have the benefits of personalised tuition for at least part of every lesson, which would ensure that their own needs were individually addressed, and then to have time for group work, when the student can offer contributions and listen to those made by fellow students and the teacher” (2018, p.73).

In view of the challenges and opportunities presented by the pandemic, the next section

discusses the way forward and deliberates on ways to integrate AI in education to provide creative solutions to some of the issues discussed above.

2.3. The Way Forward with New Technologies in Education

The global pandemic has further reinforced the need of utilising the full value of integration of new technologies and human interactions. Research and conversations around online learning convey important shifts in ways digital technology will continue to play a significant role in education in future. The pandemic and several national lockdowns worldwide also witnessed a large-scale reliance on learning management platforms, interactive digital learning environments, use of Intelligent Tutoring Systems and AI applications, to facilitate remote learning in international schools. Hence, it is of significance to discuss the potential role and benefits of using AI in Education.

Artificial Intelligence in Education (AIEd)

The idea of Artificial Intelligence in Education (AIEd) is not a new one, it has been researched and debated for more than 30 years (Zawacki-Richter et al., 2019). AI in Education is an umbrella term used to describe the use of a range of technologies from machine learning, natural language processing, data mining, algorithms, and neural networks to improvise the learning environments (Baker and Smith, 2019). A broad definition of AI provided by Baker and Smith (2019, p.10) explains, “Computers which perform cognitive tasks, usually associated with human minds, particularly learning and problem-solving.”

AI in Education is envisaged to drive efficiency by streamlining mundane administrative tasks, redesigning learning platforms, and personalising learning for the students. The system that supports the personalised learning process is the adaptive learning system. The term adaptive is defined as “able to change, when necessary, in order to deal with different situations” (Fröschl, 2005, p.11). In the learning context, the adaptive learning system must have ability to change its action to provide learning content and pedagogic environment/method for every student in accordance with her/his individual characteristics such as knowledge, goal, experience, interest, background... when these characteristics vary from person to person and are structured in user model or learner model (Fröschl, 2005, p.27). The adaptive learning system is tailored to facilitate interaction between learners and computers. This provides individual tutoring and support to learners, an area which is in the present context quite challenging for the teachers due to many students in a classroom and an enormous number of administrative tasks assigned to the teacher. An adaptive learning platform aims to deliver content, assess, and suitably modify student learning paths, allowing students to move at their own pace. It allows the teachers to manage the individualised learning paths of a large range of students on a one-to-one basis.

AI in Education functions based on three models: a) Pedagogical Model which represents effective approaches to teaching and learning. It includes knowledge of instructional approaches, learning theories and feedback. b) Domain Model which represents subject content. It aims to help the student to gain an understanding of the subject knowledge for example a topic or procedure in physics. c) Learner Model: which represents the student. The knowledge stored about the student helps in making predictions about which teaching approach and what subject content will be suitable for the learner (Luckin et al., 2016, p.19).

Though the area of AI in Education is a burgeoning field of research a lot of groundwork has already been done by the researchers on the implications of AI in educational settings. There are critical sociological and ethical perspectives on the implications of AI published by several authors like Neil Selwyn, Kelly Joyce, Susan Bell, Jean-Philippe Deranty, Thomas Corbin, Zheng Liu, and many others however, those areas were not the central focus of my research and did not respond to the research questions outlined for this study. Hence, in the context of

my doctoral research, I have grounded it in the literature focusing on the potential benefits of AI in personalising teaching and learning. Thus, I would like to address the findings from two reports based on empirical case studies to identify significant areas for the design and implementation of AI in Education.

Nesta (National Endowment for Science, Technology and the Arts, UK) released a report titled, "*Educ-AI-tion Rebooted? Exploring the future of artificial intelligence in schools and colleges*" by Toby Baker and Laurie Smith with Nandra Anissa in February 2019. The report captures three categories of AI drawing data from 8 different case studies (Baker & Smith, 2019) those have been briefly discussed below.

The first *Case Study-CENTURY* addresses an adaptive learning platform that identifies student strengths, weaknesses, and gaps in knowledge through diagnostic tests and formative assessment and structures appropriate support and scaffolding (Baker & Smith, 2019, p.11).

The second *Case Study-Class Charts* discusses another AI application to support teachers in managing classroom behaviour using an automated seated plan. It aims to save teachers time, support student monitoring, and reduce workload through data-rich seating plans that reduce behaviour problems (Baker & Smith, 2019, p.13).

The third *Case Study-Targeting school inspections* discusses ways AI applications can make predictions about a school's performance in an inspection using the progress and attainment data, school workforce census data, and parental view responses (Baker & Smith, 2019, p.14).

The *fourth case study* discusses 'Ada' developed by Bolton College, a further education college in Greater Manchester. 'Ada' is a digital assistant that is built using IBM Watson, it uses natural language processing to detect the type of query and redirect it to the most appropriate member of the staff (Baker & Smith, 2019, p.16).

The *fifth case study: Third Space Learning* which is based on system-facing AI principles. It provides one-to-one tuition using the Internet and by connecting students in classrooms with teachers around the world (Baker & Smith, 2019, p.17).

The *seventh case study is Edulai*, presents an assessment application and assess employability skills for example critical thinking, problem-solving, communication and leadership. It facilitates collaboration on group projects while students learn from the content which is made accessible by the application (Baker & Smith, 2019, p.42).

The *eighth case study is, Plymouth School of Creative Arts and Emoti-OS – Towards a collective intelligence?* This involves two interfaces: a chat bot and an emoji-based interface. The collective mood of the school at any given time is reflected on a large screen in the school atrium. This enables the school leadership and staff to make informed judgements about the issues and improve well-being(Baker & Smith, 2019, p.44).

The article, "*Designing educational technologies in the age of AI: A learning science-driven approach*" by Rosemary Luckin and Mutlu Cukurova is another important article that informs the development and implementation of AI in education and training based on the applications of learning sciences. The rapid growth of technology has witnessed an increase in data collection and analysis in educational settings. More universities and educational settings are utilising data to track learners progress and gain an understanding of learners' contexts, some of these measures include eye-tracking, physical movement and facial recognition for emotion detection widely used across the world (Blikstein, 2013). Additionally, there has been a notable increase in the number of educational settings using online learning platforms to facilitate the delivery of learning tasks, homework, assessments and communication with parents or other

stakeholders. Some of these online learning platforms also facilitate tracking or recording student progress (Ferguson, 2012; Tempelaar, Rienties, & Giesbers, 2015).

This article elucidates three vital empirical case studies demonstrating the development of AI using the principles of LA and EDM (Luckin & Cukurova, 2019). The *first Case study PELARS* (<http://www.pelars.eu>) was undertaken by the UCL knowledge lab. The project focused on practice-based experiential learning analytics to explore four constructs from the learning sciences: synchrony, individual accountability, equality and intraindividual variability (Cukurova et al., 2018). These constructs were used as probable observable features of effective collaborative problem solving (CPS) to design a multimodal Learning Analytics system for detecting these qualities automatically (Spikol et al., 2018).

The second case study is based on CENTURY Tech (see <https://www.century.tech>) which is a commercial AI platform that is focused on improving learning outcomes and addressing the achievement gaps (Luckin & Cukurova, 2019). It has been developed using the principles of learning sciences, informed by findings from cognitive and neuroscience. CENTURY has applied the principles of spaced learning to design the learning “nuggets” that focus on small topics of learning followed by a formative assessment. The principles of spaced learning stress information being easily acquired if it is delivered through short time slots and repeated multiple times providing a sufficient time gap between each attempt (Cepeda et al., 2006). One of the case studies by NESTA has addressed CENTURY Tech and that has been discussed above.

The third Case study DebateMate (see <https://debatemate.com>) is focused on personality features and skills for argumentation and debate. This case study is informed by a review of literature from learning science to emphasise on tutor characteristics (Evagorou & Dillon, 2011; Zohar, 2008) specifically, tutors’ personal (Klassen & Tze, 2014), emotional (Battistich, Schaps, Watson, Solomon, & Lewis, 2000) and social traits (Lee et al., 2014) cited in (Cukurova, Kent, & Luckin, 2019). Data in this study was collected based on psychometric measures to understand the personality traits and OpenSMILE software was deployed to predict the emotional attributes of the tutors (Cukurova, Kent, & Luckin, 2019).

A recent research publication titled, ‘*Empowering Educators to be AI ready*’ elucidates the concept of *AI Readiness* along with a framework for AI readiness training. The concept of *AI Readiness* is aimed at developing an understanding amongst educators of what AI is and ways to leverage it to benefit their students (Luckin et al., 2022). The increased implementation of AI in practice by educators and students will enhance their understanding of what it can achieve (Luckin and Cukurova, 2019). The concept further elaborates on four aspects which organisations and educators must identify in becoming AI-ready. These include addressing the following questions:

- a) What activity or challenge within their organisation will be best addressed by deploying AI and a data driven approach.
- b) Where AI can be best applied in their organisation (For instance for teacher development or recruitment of staff).
- c) Why AI is to identify the unique contribution it will bring to the organisation.
- d) Who will be involved in this process addresses identifying the stakeholders to further contextualise the AI readiness (as in Luckin et al., 2022).

The concept stresses on empowering people in an organisation for equitable implementation of AI practices in educational settings. The paper proposes the AI-ready concept leads to the development of AI readiness framework to assist the educational organisations to adopt and benefit from AI technology (Luckin et al., 2022). The design of the framework has been informed by the Organisational Readiness CRISP-DM iterative cycle which includes Business

and Data understanding, Data preparation, Modelling, Evaluation and Deployment (Wirth & Hipp, 2000).

The 7 step Ethical AI readiness framework includes the following (as in Luckin et.al, 2022).

Step 1. EXCITE—involves exploring ways to develop AI readiness and engaging its staff in the process.

Step 2. TAILOR AND HONE—involves identifying the challenges and selecting 1-3 challenges for AI readiness keeping the organisational vision in focus.

Step 3. IDENTIFY- involves accessing and collating the data.

Step 4. COLLECT- involves exploring the new data collection, several practicalities, and methods of data collection.

Step 5. APPLY—involves identifying AI techniques relevant for data collection.

Step 6. LEARN—involves reflection on the application and use of AI.

Step 7. ITERATE involves another iteration of the approach has not met the objectives.

To summarise, the design of AI Readiness training programme stresses on contextualising the requirements in an educational organisation to identify and collect data, apply AI approaches, and learn from the outcomes. The 7 step ETHICAL AI Readiness framework offers a structure to further support the educational organisations to build AI training (Luckin et al., 2022).

These case studies and expansions concerning the implementation and future development of AIEd are indicative of the significant progress made by the adaptive learning models in education. It is evident that AI is changing the way we live and work (Posner & Fei Fei, 2020). This makes it possible to personalise instruction and encourage self-paced and self-directed learning. It also has the potential to play a key role in addressing the educational access issues in the regions where there is a paucity of qualified staff or in scenarios such as the recent pandemic.

The review of the published literature suggests that AI in Education offers a promising approach to improving formative learning approaches enabling personalised instruction and autonomous learning. However, at the implementation level, these technologies remain unexplored in most international schools' owing to contextual and financial barriers that obstruct access to these new technologies. Nonetheless, the recent global pandemic has established a clear need for a new road map to respond to these new opportunities and challenges and to successfully manage the transition to new ways of learning based on technology-enhanced teaching and learning. The COVID-19 pandemic has elucidated that the present education models across the globe are losing their relevance in an era of constant change as they are largely focused on measuring learning based on set standards. Whilst the use of computers and AI is expected to facilitate expeditious learning and may potentially enhance learning performance, it will be fair to underline the need for assessment reforms and their relevance to the evolving education system (as specified in the case studies above). While envisioning the implementation of these new technologies the ethical implications of the governance of personal data must be carefully considered by different stakeholders.

These understandings and expansions also substantiate the significant claim of Vygotsky's theory that instruction is most efficient when students engage in activities within a supportive learning environment and when they receive appropriate guidance that is mediated by tools (Vygotsky, 1978). This has been further elaborated in the next section.

2.4. Zone of Proximal Development (ZPD) and Technology Enhanced Learning (TEL)

The theoretical foundations of this study are informed and based on the work of Russian Psychologist, Lev Vygotsky, and his popular notion of the Zone of Proximal Development (ZPD).

A recognised and empirically established fact is that learning should be matched in some manner with the child's developmental level (Vygotsky, 1978, p.85). Vygotsky unlike Piaget stresses learning as a precondition for the child to develop "culturally organized, specifically human psychological functions" (Vygotsky, 1978). These socio-cultural perspectives of Vygotsky encapsulate that learning contributes to development, "this provides the basis for the subsequent development of a variety of highly complex internal processes in children's thinking" (Vygotsky, 1978, p.90).

Vygotsky further defines the relationship between learning and development in his theory of Zone of Proximal development (ZPD). He proposes that the first level of development can be called the actual developmental level, which specifies the level of development of a child's mental functions that get established because of already completed developmental cycles (Vygotsky, 1978, p.85). Vygotsky describes ZPD as "*the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem-solving under adult guidance or in collaboration with more capable peers*". This definition highlights the two stages of development a) the actual developmental level where the learner can perform independently and b) the potential developmental level, which the learner attains with the help of a competent other. Vygotsky proposed the concept of Zone of Proximal Development to draw attention on the relationship between instruction and the process of development. It thus highlights the mental functions that have yet not matured and can be furthered with the help of teachers, peers, or more knowledgeable others (Vygotsky, 1978, p.86).

There are several implications evolving from this definition and must be considered while furthering the understanding of ZPD in the context of TEL. Firstly, independent problem-solving stresses self-directed and more autonomous learning amongst the learners. Secondly, the idea of scaffolding learning emerges from guidance and collaboration with more capable peers. In the context of Technology Enhanced Learning, the above guidance, collaboration, and support are offered with the technology tools or applications. These instructional tools/applications can be defined as "cognitive strategies, a mentor, peers, computers, printed materials, or any instrument that organises and provides information for the learner." Their role is "to organise dynamic support to help [learners] complete a task near the upper end of their zone of proximal development and then to systematically withdraw this support as the learner moves to higher levels of confidence" (Patsula, 1999).

Another possible implication of Vygotsky's ZPD is that the mediation and help of the more able partner results in improving the learner's rate of learning which in the context of TEL is offered by the digital applications. These understandings have informed further research about ways technology can be leveraged to model context and its impact on learning. It has led to a design framework that has been successfully applied across a range of educational settings (Luckin and du Boulay, 2015). Research further suggests that Vygotsky's ZPD (1978) may be used to inform the design and development of educational technology to facilitate explorations into ways to scaffold learners' metacognition, scaffold learners' motivation and the implications of a learner's goal orientation upon their use of these technologies (Luckin and du Boulay, 2015).

Furthermore, the rapid pace of technological advancement and the use of digital applications in teaching and learning has resulted in large data sets arising from learners' interactions with the technology. This has shaped a new field of Learning Analytics that explores attributes, behaviours other associated elements of learners' performance. The academic progress, attitudes, and behaviour of the learners are now tracked using large data sets in educational settings that enable identifying sources of assistance and interpreting learners' context (Luckin and du Boulay, 2015). This understanding of learners' context has further reinforced the scaffolding process. In the context of this study, the use of digital technology serves as the mediating tool to support the learner's development to the next stage.

3. Methodology

This study follows a mixed-methods research design (Tashakkori & Teddlie, 2003) which is a combination of quantitative and qualitative approaches to gather and analyse data and to gain understanding of a research problem completely (Creswell, 2002). The quantitative aspect of this research constitutes a survey that aims at exploring initial views of the respondents on the issues under investigation by providing "descriptions of situations or phenomena in a systematic and comparable way" (Punch, 2014, p.307). The qualitative aspect of this research complements the quantitative data for generating personal interpretations and accounts through an in-depth investigation using individual semi-structured interviews.

3.1. Epistemology and Ontology

In terms of epistemological and ontological views, this study is based on a pragmatist paradigm. Pragmatism as a research paradigm is not based on a particular philosophy or reality hence instead of focusing on methods, it allows the researcher to emphasise on the research problem and use all possible approaches, to derive knowledge about the problem (see Rossman & Wilson, 1985). This approach allows flexibility to integrate multiple methods, different worldviews, assumptions, forms of data collection and analysis as opposed to positivists/postpositivist and constructivist approaches that have a more rigid understanding of the nature of reality and conduct of research. Furthermore, COVID-19 had imposed a lot of uncertainty and restrictions, my research design had undergone changes several times, having a pragmatist approach allowed me greater flexibility to focus on investigating the research problem and responding to the research questions incorporating different approaches in this study.

3.2. Data Collection

The study initially was designed as a single site qualitative case study to explore the role of formative assessments and its impact on the learning experiences of students in the IBDP. I had planned to conduct this case study in an international school in Surrey, UK that had agreed to host me in person for a period of several months. However, in view of the outspread of global pandemic and shift to online teaching and learning in early 2020, the planned field work for my proposed research had to undergo several changes. The COVID-19 pandemic made it extremely challenging for me to conduct the data collection as the school was forced to close several times during the national lockdowns in the UK. In view of the school closure in early 2020, the school offered to host me from August 2020-February 2021. But in view of the government regulations, health, and safety norms due to the pandemic, the school further placed restrictions on visitors to the school campus which made it impossible for me to visit in person even when staff and students were back on the school campus. Hence, it was decided in July 2020 that I will conduct the field research virtually with the school. This shift to virtual data collection needed to completely re-think my methodology, including designing alternative (virtual) ways of gathering data from the school. I redesigned several aspects of my research,

designed Study A to additionally collect data from the teachers in IBDP schools worldwide, reviewed the research questions and the data collection methods to appropriately fit the virtual data collection.

The data collection was done using three predetermined variables- 'Learning Environment, Curriculum and Pedagogy, Assessment and Feedback.' These variables were measured on a 4-point Likert scale from Strongly Agree, Agree to Disagree and Strongly Disagree along with open-ended questions using an online survey. Furthermore, data from the open-ended comments in the survey and comments from the follow up qualitative interviews were interwoven with the quantitative data to elaborate on the findings throughout the report. The data collection was conducted in the two phases for Studies A and B as discussed below.

3.2.1. Study A- Research Project (IBDP Teachers/Coordinators)

The global pandemic recently caused a major shift to online teaching and learning across the globe. This research project explores the factors impacting the teaching and learning in the context of the IB Diploma Programme. It aimed to analyse perspectives of the IB Diploma Programme teachers and coordinators on the use of digital technology in teaching and learning, and ways in which this shift has impacted their pedagogical approaches. Data collected includes an online teachers survey and follow up in depth (online) interviews.

3.2.2. Study B- A Case Study

An in-depth small scale case study which was conducted at an international school in the UK. The study aimed to explore the implementation of AI for the teaching and learning of mathematics at the secondary level. Data collected includes online student survey and follow up online interviews with students, and the mathematics teacher.

The figure below represents methodology design showing two phases of data collection.

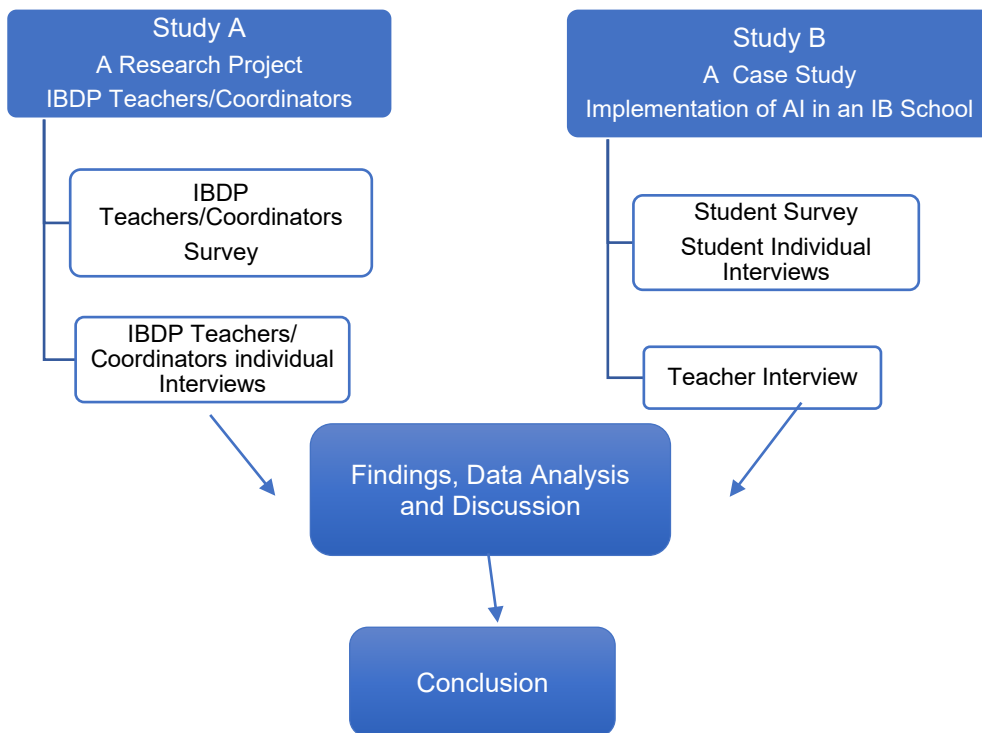


Figure 1: Methodology design showing two phases of data collection

3.3. Data Analysis

To analyse the quantitative data in this study, I used descriptive statistics which is concerned with the enumeration and organisation of the data. Therefore, percentages and summary tables were used as forms of graphical representation to present the data in Study A (See Appendix C). Since the data in Study B was small it was presented in numbers instead of percentages (See Appendix C1). For the qualitative interview data, I followed the phases as outlined by Creswell (2009). The data was then organised in themes based on Braun & Clarke's thematic analysis approach (2006). The stages in which interview data were analysed involves familiarisation with the data, generating codes, searching for themes, and naming the themes. Braun & Clarke (2006, p.78) suggest that it is the first qualitative method that should be learned as 'it provides core skills that will be useful for conducting many other kinds of analysis'. Moreover, I viewed the data from a pragmatist perspective, describing the "experiences, meanings, and the reality of participants.....and the way the broader social context impinges on these meanings" (Braun & Clarke, 2006).

As Braun & Clarke (2006) describe thematic analysis offers the flexibility and allows the researchers judgment to determine themes in several ways, however, it is important that researchers are consistent in how this is done (Nowell et al., 2017). To remain consistent with my approach, I began the analysis by taking an initial deductive approach which involved mapping the research questions to interview schedule and to the participants responses to ensure that the data in the study was appropriately organised and important information is not missed. During the analysis, I identified the ideas and constructed themes from the data inductively. Inductive analysis is a process of coding the data without trying to fit it into a pre-existing coding frame or the researcher's analytic preconceptions (Braun & Clarke, 2006). With an inductive approach, the constructed themes were based on a data driven approach (Nowell et al., 2017). I used open coding which implies that there were no pre-set categories or codes used for data analysis. The codes were identified, reviewed and regrouped throughout the coding process. The open coding offers flexibility during the analysis process as the codes can change and evolve during the coding process while regrouping the categories and patterns emerging from the data. As Braun & Clarke (2006) suggested sections of text can be coded in as many different themes as they fit, being uncoded, coded once, or coded as many times as deemed relevant by the researcher. I also ensured to include accounts that depart from the dominant story in the analysis while coding the data set and categorised them under miscellaneous themes(Braun & Clarke, 2006).

The codes which were directly related to the words of the participants were carefully examined to identify the emerging themes. The emerging themes described patterns in the data relevant to the research questions. I also analysed and coded the open-ended comments from the quantitative survey data following similar steps. I examined the patterns and characteristics emerging from the quantitative open-ended comments to establish connections with the qualitative data in this study. This further helped me to triangulate the quantitative and qualitative data and compare the emerging themes. The themes emerging from Studies A and B were later compared with the ideas developed in the literature review and the research questions and those are elaborated in the discussion section.

3.4. Ethical Considerations

To conduct this study, I had obtained ethical approval from the University of Bath. In this study, I ensured that the identity of the participants was kept strictly anonymous and was not disclosed in any write-up of data. I ensured complete anonymity with reference to the research site, participants and the EdTech company providing the AI application. Furthermore, any contextual information that might provide an indication of the research setting was avoided

and as necessary, redacted. I used Google forms for obtaining parent/guardian and students consent for the case study conducted in the international school. The consent for the online interviews from the teachers in IB schools was obtained via email. All participation in this study was voluntary. Participants were advised and reminded of their right to withdraw from the study at any time without consequence or need for justification. The consent forms clearly communicated to the participants the right to withdraw from the study. The forms addressed the confidentiality of data and information related to the participants in this study. During my research, I worked within the British Educational Research Association Guidelines (BERA, 2018) and ethical guidelines of the University of Bath.

4. Research Findings

The findings reflect data collected through online surveys and follow up individual interviews in Studies A and B.

4.1. Study A

Study A aimed to analyse the perspectives of the IB Diploma teachers/coordinators on the use of digital technology in teaching and learning. The COVID-19 pandemic recently has caused a major shift to online teaching and learning across the globe.

The participants in this study were 80 IB Diploma Programme (DP) teachers, coordinators, and administrators. The survey responses reflect 82.1% IBDP subject teachers, 17.9% IBDP coordinators and 9% in the other category includes responses from heads of school, vice-principal, associate DP coordinator and heads of department.

The survey responses reflect participants across China, India, Japan, Bangladesh, Indonesia, Italy, Switzerland, the UK, USA, Egypt, Tanzania, and Turkey. The survey responses indicate that 65.8% of the IBDP teachers/coordinators were involved in a complete online teaching mode, 27.8% were using a mix of face to face and online teaching and only 6.3% were teaching in a complete face to face setting at the time of completing this survey.

The follow-up interview data include participants from Indonesia, Tanzania, Bangladesh, China, and India.

4.1.1. The findings in this section discuss the *transitioning experiences* of IBDP teachers to online teaching during school closure due to the global pandemic. The findings in this section address research question 1 and research objective 1.1. This question was completed by 79 participants.

The findings from the survey responses (Appendix C-Table1) and the interview data demonstrate several challenges experienced by the IBDP teachers in relation to school support and digital infrastructure that impacted their teaching in responding to the COVID-19 pandemic. The findings demonstrate that respondents generally agreed around having a supportive organisational culture for innovation in teaching and learning during the transition to online teaching due to the pandemic. The findings reflect respondents mostly agreed to have a reliable digital infrastructure to support teaching and learning, to have a set of clear safety protocols for the use of digital technology in teaching and learning that consequently facilitated transition to online teaching. The findings further indicate greater agreement to have opportunities for personalised learning experiences for learners and opportunities for teachers to engage learners as active participants in the digital learning process.

The findings demonstrate diversity around responses for continuous up-skilling opportunities to use digital technology within their subject and beyond, and access to a wide range of digital

resources which represent individual training needs of the teachers, different school contexts and diverse approaches to address the above requirements. A notable diversity in views was reported around opportunities for learners to be self-directed through flexible curricular choices. These contrasting perspectives insinuate contextual differences and underlying issues in the respective areas in the IBDP. The emerging issues include frequent power cuts, restrictions on Wi-Fi access in certain countries and poor internet connectivity faced by students and teachers that hampered online teaching-learning and assessments. Likewise, the findings reveal certain country-specific norms that restricted access to educational websites and learning material adding to the challenges of the teachers in the effective implementation of teaching and learning. The findings reveal in some contexts, the cost of providing mobile data was exceptionally high and only a few students had access to computers and laptops at home which obstructed the online delivery during lockdown due to the global pandemic.

Furthermore, most teachers expressed that they found it challenging in the beginning of the online teaching to incorporate digital methods into teaching as the time passed, they got accustomed to the new digital technology and felt they were exploring a new world which consequently had a positive impact on their teaching. An interesting finding that emerged consistently across all interviews was in relation to the learning environment. The teachers expressed at the time of the sudden shift to online teaching they began with a largely asynchronous schedule to keep the schedule flexible for the students and then slowly moved to an online schedule where students were expected to follow a daily timetable however, the lesson timings were reduced. It serves as a prominent finding as the implications of reducing the lesson timings were elucidated by the teachers while responding to the challenges regarding effective curriculum delivery during this period. Furthermore, teachers and administrators in some schools had undertaken extra efforts to recreate a similar learning environment online as the students had in a physical classroom due to parental demands and insistence. This implied that the school had to procure whiteboards and extra cameras during the lockdown to be installed at the teachers' residences to create a classroom environment though there were technical alternatives the parents refused to accept them. Consequently, this caused additional challenges and had financial implications for the school in a period of uncertainty and turmoil.

Likewise, the responses related to access to digital infrastructure and learning management platforms encapsulate a range of diverse experiences of the teachers that stress the individual context. Few teachers expressed that there were frequent changes to the technology platform during the transition to online teaching which consumed lot of their time and efforts. They shared that trying out a new technology platform and then finding its limitations added to their transitioning challenges and frustration. On the contrary, in the schools that had established digital platforms and technical processes before the pandemic, it was already embedded in their routine, students, and staff were well versed with the platforms for collaborating and communicating and consequently, they have reported switching swiftly to online teaching.

The findings demonstrate most used technology platforms in schools during the online teaching phase were Zoom, Google Docs, E-Books, Presentation software, Mobile devices, and Microsoft Office 365. The responses reflect lesser use of digital field trips, Moodle, Virtual Reality (VR) Model, Augmented Reality Model & Apple Teacher which indicates that the schools explored a limited range of digital technology platforms. The data demonstrates limited use of AI learning platforms during online teaching in the IBDP schools suggesting that implementation of new emerging technologies was confined to very few schools (Appendix C-Table 2).

Moreover, the findings reveal lack of consistent and reliable learning management platforms amplified the personal challenges of the teachers since the frequent changes to the platforms

in some settings were time-consuming for the teachers. Additionally, some of the personal challenges experienced by the teachers were related to health and well-being that involved long office hours including working in the evenings and over the weekends that impacted their family responsibilities. The findings show long exposure to digital technology during online teaching caused severe well-being concerns and physical fatigue which impacted the health of the teachers. Similarly, the pandemic caused personal losses for many students which affected their emotional and mental health and consequently impacted their engagement levels during online teaching.

Interestingly, teachers expressed that the pandemic taught them several new skills specifically digital skills, using online resources and different digital platforms for teaching and learning that they had not used earlier. Moreover, teachers reported that several professional development activities organised by the schools to adapt to online teaching came as immense support during the transition to online teaching. Student engagement and monitoring emerged as a challenging aspect of online teaching during the pandemic.

The comments from the follow-up qualitative interviews and open-ended comments from the survey summarise the transitioning experiences of the IBDP teachers and administrators to online teaching.

My school owners made my teachers work for extra 50 days after the end of the proposed academic calendar that we had before COVID.....so we must work over the summer vacation to compensate.....there was a leadership challenge for me to convince my teachers who were completely burnt out by the end of the year, they had not seen the family since March 2020 and they were frustrated, asking them to work for another 50 days was a nightmare for me and managing that situation was terrible.

Access to the internet is a major challenge in our context, the internet data is quite expensive, and the students are not that equipped with the technology like not everybody has a mobile, smartphone or a computer, so 60- 70% don't have access to these things and only 30-40% have been provided data facility by the parents which makes the online teaching and learning extremely challenging in our context.

Our school's policy allows students to keep their cameras off for child's online safety reasons. It is extremely difficult to communicate with students who are not engaged when you cannot see them I am losing some students who are not participating at all in class..... The achievement gap seems to be growing and it is very worrying to see some students hardly engaging with lessons.

XXXXX culture does not appreciate and value online teaching. The school owner, parents and student community do not believe that learning can happen without a classroom and face-to-face interaction. I had to supplement the days that we had online classes during COVID-19 with face-to-face classes by extending working hours and calendar days of the academic year.

Furthermore, in certain contexts, to demonstrate that online teaching offered the same value as face-to-face teaching, several schools extended their working hours and days in the academic calendar. Consequently, this lack of flexible approach and rigid school policies impeded the learning process and contributed to issues concerning student engagement which subsequently impacted the academic achievements of the students during this period. The analysis reveals these transition challenges led to mental, emotional, and physical fatigue amongst teachers causing serious well-being concerns.

Additionally, the IBDP administrators (in this case mostly coordinators) point out the leadership challenges arising during this transition to online teaching. Some of the issues arising from the findings reveal time tabling and scheduling online classes was challenging due to geographical distribution of students during several lockdowns in different time zones. The schools had to repeat several teaching sessions to include students in different time zones this resulted in excessive teacher workload and eventually a complete burn out of teachers in some schools. It was found that parental expectations to replicate the physical classroom set-up, additional working days to demonstrate that online teaching was meeting the same expectations of face-to-face teaching added up to the administrative challenges and had financial implications for that school. The analysis therefore demonstrates several leadership constraints in managing the transition to online teaching and implementation of several aspects of learning during this period.

The quantitative and qualitative data in this section encapsulates key issues related to the use of digital technology in the IBDP during online teaching due to the pandemic. The analysis reveals similar categories or clusters of emerging concepts and patterns from the quantitative and qualitative data sets which present diverse experiences and contextual challenges of the IBDP teachers and administrators (in this case mostly coordinators) during the transition to online teaching caused due to the pandemic. To summarise the issues arising from the findings access to reliable and consistent digital infrastructure and tools including digital resources emerge as a central concern that consequently led to difficulties in the planning and delivery of online teaching including teaching schedules, subject-specific challenges in content delivery, issues related to well-being, classroom management and student engagement. The findings reinforce the professional development needs of the teachers arising in view of the sudden shift caused due to the pandemic. Similarly, an analysis of the findings elaborates on some of the administrative challenges encountered by the school leadership that include managing parental expectations, access and availability to digital resources, online timetabling challenges, student engagement, health and well-being concerns of the staff and students and local government regulations pertaining to the pandemic.

4.1.2. This section presents the issues in relation to *technology-led curriculum and pedagogy* in the IBDP. It addresses research findings under research objective 1.2 in this study. This survey question was completed by 79 participants.

The survey data (See Appendix C-Table 3) and the interview responses reveal ways in which the use of digital technology impacted the teaching approaches in response to the COVID-19 pandemic which presents varied challenges of the teachers.

The findings demonstrate teachers generally agreed regarding delivering the content in their subject with confidence. Many respondents agreed using a range of teaching strategies to improve learners' engagement, to incorporate online tools that enable learners to access content and learn at their own pace, integrate complex concepts in a creative manner and to integrate real-life connections within their subject and beyond. The responses reflect agreement and consensus around collaborative learning opportunities within their subject and beyond, and to provide individualised support to learners with varying learning needs. Similarly, most respondents agreed to develop skills consistent with internal assessment tasks, and to focus on research skills consistent with Extended Essays.

Interestingly, the responses to differentiate tasks based on content and skill reflect the most diversity. Similar diversity in the responses is notable about incorporating inquiry-based approaches effectively and enhancing the relationship with learners through ongoing interaction and dialogue around the learning process. Another prominent disagreement was reflected about designing learning tasks focused on the individual learning abilities of learners and to provide individualised support to learners with varying learning needs. These

differences and diversity in views suggest issues and contextual challenges that were explored further through the open-ended comments in the survey and the qualitative interview data. Teachers shared several subject-specific challenges while delivering the content online for instance, teaching complex concepts in economics, using simulations in sciences and geography to explain different models online was difficult. Another issue was large group sizes online made it difficult for the teachers to provide individual support and address the differentiated teaching needs. It can be inferred from the findings that these challenges further led to student engagement issues in the online classroom. Likewise, some other pedagogical challenges include conducting activities that involved group work online, teaching languages and the associated skills in Groups 1 and 2 subjects was found challenging. Moreover, the views expressed in the open-ended survey responses demonstrate that teachers endorsed the implementation of centralised digital platforms/applications where content can be uploaded, and students can access it at their own pace.

These initial perspectives collected through the online survey were further investigated through qualitative individual interviews with IBDP teachers/coordinators in different contexts. The interview responses further elucidate ways in which the use of digital technology impacted the teaching approaches in response to the COVID-19 pandemic which presents varied challenges of the teachers.

The qualitative findings demonstrate that most schools were unprepared to deal with this massive shift to online teaching and learning. Few teachers expressed that they would prefer face-to-face teaching as they were not satisfied with the way content is delivered digitally. The teachers generally found it challenging to develop digital content and relied on common internet websites and YouTube resources. They reported using a lot of tutorials, notes, animations, and simulations that were available on the internet and all these resources also helped the students. Teachers created all the digital teaching resources like videos and worksheets which was time-consuming and made the online content delivery difficult. They recognised their struggles in identifying alternate ways to incorporate digital lessons to help the students. On the contrary, the schools with established digital repositories or platforms for digital resources found online content delivery imposed no difficulties on their teachers. Several teachers expressed it was difficult to maintain a learner portfolio online whilst the teachers who were already using a learning management platform prior to the pandemic found it relatively easier.

The findings reveal Internal assessments (IA) and Extended Essays (EE) components in the IBDP posed the greatest challenge due to the lack of organised digital resources to support the process. Some teachers expressed that they only had access to free resources and the school did not subscribe to other online tools and resources which constrained the delivery of these components. Teachers expressed difficulties in finding substitutes for collecting primary data for IA and EE using online tools. Similarly, identifying relevant secondary sources for a given topic and processing the data was an area where teachers encountered difficulties. Moreover, challenges associated with learning environments at home including lack of access to appropriate digital set up further impeded the delivery of these components.

Moreover, the findings demonstrate in many cases, online teaching was used as a substitute for offline learning and not as an efficient alternative. The teachers shared using the same pedagogical approaches which they used offline while teaching online too, some of them shared they replicated the same timetable and teaching strategies and realised that it does not work in the online environment. This suggests that teachers needed more clarity and training on ways to incorporate digital technology efficiently. In few contexts, teachers expressed concerns regarding the lack of flexibility in organising online lesson delivery. They reported to have been directed to conduct all the lessons online rather than having the flexibility to hold some lessons asynchronously and allow students to manage their screen time in smaller chunks. Views such these reveal contextual challenges, individual school

policies, and approaches by schools to organise online learning. Similarly, teachers in few other contexts reported that content delivery was hindered since students were spread in different geographical locations during lockdown where they did not have the same access to technology. Teachers further shared that an asynchronous format of content delivery was implemented for those students based in countries like Syria or Palestine or other areas experiencing war like situations. The lesson recordings were shared with those students. The comments below further encapsulate teachers' views regarding pedagogical challenges.

Content delivery was significantly influenced as I could not explore many mediums in my subjects digitally. It was very limited. Art supplies were a big challenge so I had limited art resources to facilitate my teaching online.....

*I teach economics which is a content-based subject that is full of diagrams and the connection with the real world so it's easy to deliver it in a face-to-face classroom.....
.....it's very difficult for me to draw the diagrams online and if I use different tools to draw that diagram it's difficult to make them understand that virtually.....*

Practical & IA's need serious development, there are resources on the internet and they are scattered, additionally, those resources are mostly paid. It is not possible for students and teachers to purchase it..... If support for experimental design and experimental pieces of knowledge could be shared at one place that could have been easier for learners to access and to gain practical skills better.

The home environment did not afford to learn as many students in XXXX were confined to small spaces. Hence it was challenging to build rapport and ensure participation. Collaborative strategies and personalised slots with students in the first term ensured that students were more open and freer to communicate and address their concerns.

The teachers and students in their feedback shared that they miss the social interaction that gave the joy of being in the class..... that was the 30% learning which is not related to the academic subjects which is the learning of the affective skills that we talk about in the IB..... those ATL skills were missed.

The views above elucidate pedagogical challenges encountered by the IBDP teachers /coordinators during online teaching. Some of the other factors that impeded effective online curriculum delivery include a lack of enabling learning environment at home during the lockdown period, dealing with personal losses due to the pandemic, and strenuous online teaching schedules led to student fatigue that hindered the quality and flow of instruction during much of the online year.

The quantitative and qualitative data in this section encapsulates vital issues that need specific pedagogic support to incorporate digital technology effectively in the IBDP which include access to quality content and more subject-specific resources, explaining content and extended concepts to students in an online environment, student-friendly instructional aids, online assessment tools for the IBDP, collaboration and group work for students. Lack of collaborative time for teachers during online teaching has emerged as a notable concern, school runs with very little collaborative time scheduled that needs redressal to extend pedagogical support. Moreover, findings indicate the need for more research and investigation related work and formal training opportunities for the teachers in the IBDP. Teachers suggested a more flexible curriculum at the DP level might ease the pressure on the teachers.

The findings illuminate differentiated instruction as an area of significant challenge and needing more pedagogic support in the online curriculum delivery. It requires a variety of strategies and practices other than break out rooms and specific study material. The findings reveal several challenges in creating study material for differentiated learning, maintaining a

learner portfolio for differentiation, identifying differentiated instruction and assessment tools for the IBDP. Some other issues include online monitoring learners and maintaining learners' portfolios, the well-being of students, personal challenges, and the professional development needs of the teachers. Additionally, the lack of social interaction- the social aspect of learning was something missed equally by students and teachers during the online teaching.

4.1.3. This section present findings in relation to design and conduct of digital assessments in the IBDP and responds to research objective 1.3 in this study. This survey question was completed by 79 participants.

The findings from the survey responses (Appendix C-Table 4) and the interview data demonstrate key concerns regarding the digital assessments. The issues emerging from the quantitative and qualitative findings may be grouped under three broad categories: designing, conducting, and monitoring online assessments. Data derived demonstrates most respondents agreed to explain learning objectives and goals efficiently, to implement interactive assessments in their subject. Furthermore, there has been consensus to implement efficient submission, marking, moderation and data storage in their subject and most respondents agreed to use an assessment process to inform and align their teaching practices.

Interestingly, the responses to question subsets 4.3 to 4.12 (Appendix C-Table 4) illustrate diverse perspectives. The diversity in views is reflected around responding to learners' conceptual difficulties effectively, incorporating variety in the design of assessments providing learners with a choice of topics, methods, criteria, and timings of assessments in their subject. Similar diversity in the responses was notable about incorporating online tools that enable learners to self-assess their work, providing effective, immediate, and individualised feedback, improving learner engagement with an ongoing feedback process, and monitoring individual learner progress efficiently. Conducting pre-assessment in a variety of ways for building on learners' prior knowledge further reflects mixed responses of the respondents. Consequently, this had a notable impact on capturing the wider skills not assessed by other means and that was reflected in the varied responses. Interestingly, ensuring valid results with opportunities to combine human and computer marking also illustrates notable contrast in the responses.

This diversity in perspectives also indicates underlying issues in the design, development and conduct of online assessment in the IBDP. The diversity in views may be contributed to several factors like contextual differences, access to technology tools, different attitudes, individual approaches, and experiences of teachers, these were further investigated during the qualitative interviews. Moreover, the findings demonstrate a wide range of assessment tasks were used by the teachers to conduct assessments digitally during the online teaching phase. Most used assessment tasks were individual assignments, online quizzes presentations and reflections, self-assessment, and Multiple-Choice questions. Many responses also indicate the use of peer assessment, essays, and group projects (See Appendix C-Table 5).

The findings further reveal that assessment tasks that were less often used than above tasks to assess digitally in the IBDP schools during the online teaching include lesser e-portfolios, posters, lab reports, journal blogs and open book assignments (See Appendix C-Table 5). The responses demonstrate limited use of online learning logs for digital assessment purposes. The findings here suggest an increased emphasis on individual learning through various learning tasks and assignments which also reflect ongoing assessment practices.

The teacher's responses reveal several challenges in using digital technology in designing assessments. Teachers expressed difficulties in following the IB paper exams model in an online environment, structuring multiple choice questions, analytical essays, and graph-related questions were difficult to design and implement, and marking handwritten essay-

based responses was found difficult. Assess prep, exam.net and Kognity were the most used technology platforms. Some teachers shared using MS forms to create assessments online. Teachers further reported that some of these platforms offered complete solutions at the end which students could use to for self-assessment. It was particularly helpful during the lockdown. The platforms also offered a topic-wise complete report which helped the teacher in monitoring the progress remotely. In certain settings, where online software or digital application were not available, teachers reported that designing assessments was time-consuming and difficult. Moreover, the online design of the assessments sometimes did not show all options and structured questions were split without proper segments/alignments which imposed practical constraints while conducting exams online. Besides, it emerged during the analysis that these digital platforms did not offer features to design assessment tasks for students with learning challenges which appears as an overlooked area during online teaching in the IBDP. The comments below present the views and varied experiences of the teachers.

It is challenging to create online different assessments with differentiation instructions and to monitor many students in the class doing different assessments at the same time.

It was very difficult to get students who are an introvert to speak online whereas they could be coaxed to do so in class, it was not as effective online. I will need to rethink how I can have the student hold online discussions and get quieter students involved. ...speaking is a key component of assessment in my subject.

The assessment was difficult online. My subject at least enables students to do a comparative study. I have shared two artists and they must study doing the visual analysis considering the cultural concepts and other things. During the practical assessment, the students manipulated and shared very fine pictures they just photoshop and tried to trick me. So, I felt the practical assessment was difficult, but the theory part and other things were quite okay.

These perspectives further reinforce the need for an established digital infrastructure to support effective implementation of online assessments. Most teachers expressed conducting a range of formative assessments using short assessment tasks or papers using IB questions during the lockdown. Whilst others reported moving away from test-based learning and giving students independent open questions, more project-based and research-based assignments including student presentations, and individual and group assignments which the teachers found more effectively assessed the student's skills online.

Similarly, teachers expressed enormous challenges in conducting and monitoring assessments online, main issues centred around online invigilation and academic honesty concerns. Some of the teachers suggested schools must subscribe to software or website specifically designed for digital assessment to ensure academic honesty in students' work in the IBDP. The findings indicate students were not supervised effectively while writing exams online which was due to lack of conducive environment at home, the online assessment tasks therefore lost its authenticity due to supervision difficulties. Moreover, teachers expressed that students were often tired by long screen time which subsequently led to well-being concerns, some did not want to turn their cameras on, and sometimes were difficult to get engaged in the learning. It was challenging for the teachers to conduct ongoing assessments online particularly for those students who did not respond to emails or show up in an online class. Likewise, teachers shared using different strategies and tools to make sure that the students were writing their papers and following all the protocols of integrity without having any malpractice in the online class, which was challenging in a remote setting. Difficulties in

catering for inclusive requirements for students with different abilities and planning differentiated assessments emerged as a concern for teachers.

Also, language teachers felt constrained to get students who are an introvert to speak online whilst they could be coaxed to do so in class. Teachers were compelled to rethink holding online discussions and getting these students involved as speaking is a key component of language assessments. The findings show challenges in conducting listening assessments where the student might download the tape or audio from the internet. Similarly, teachers encountered difficulties in supervising students from accessing other websites apart from the platform used for assessment. Academic honesty emerged as a central concern while conducting all forms of assessments online.

It also emerged during the discussion that schools were unable to receive their fees due to the unforeseen circumstances created by the pandemic which impacted the investments in digital resource procurement. Though this finding does not directly relate to the assessment however it did impede the support to various assessment resources in these schools. Likewise, the findings reveal several strategies were implemented by the schools to address the issues concerning academic honesty while conducting assessments online in the IBDP.

Furthermore, teachers and coordinator's shared establishing several feedback mechanisms within the school to monitor learning and provide timely support and learning interventions wherever needed. This suggests that monitoring and feedback processes during online teaching added additional work for the teachers and administrators moreover, they could only create short-term plans which were continuously reviewed and revised to meet the student's requirements. Additionally, teachers expressed difficulties in marking student work online due to the nature of assessment tasks in their subjects and the absence of adequate digital marking tools. In some cases, the nature of subject imposed challenges in marking student work online as high-resolution digital marking tools were required, these were mostly group 6 subjects.

The comments below highlight the views of IBDP teachers and coordinators on aspects of online assessments that need distinct focus in the IBDP.

Assessments in IBDP needs transformation. IB must come up with alternative ways for assessing learning than their current practice. So, my suggestion will be to have more technological support for authentic learning assessment.

Students with attention-deficit issues and hyperactivity found online assessment challenging. We had to ensure one on one monitoring with such students, in separate online rooms, so that the main cohort is not disturbed. The long hours of laptops were not easy on these students.

Digital Marking tools- it is incredibly difficult to mark a photo of handwritten work. The exams are still handwritten, so I feel strongly about training students to write well by hand. However, when they upload a photo of their work it is incredibly time-consuming to try marking their work online. I did not find a tool that I could use where I could write easily and where the students could contribute easily. I feel I lack training in this area.

I think IB must reorganise how the internal assessment is done and monitored in schools. Why can't IB come up with a plan, why the IA is still stuck at 20 to 30 per cent..... IB should adopt and look at those alternate ways of assessing and these are being done by the universities. For instance, considering a project-based approach in assessments as we did in our masters and doctorate programmes.

The quantitative and qualitative data encapsulate key issues related to designing and conducting online assessments using digital technology in the IBDP. In view of these findings assessment practices require several considerations in the IBDP to adapt to the digital transformation caused due to the global pandemic. The findings highlight a distinct need about more technological support for incorporating fair, authentic, and valid assessment practices in the IBDP. Additionally, it also necessitates considering alternative ways for assessing learning than the current practices.

4.1.4. This section presents findings in relation to independent and personalised learning opportunities to students offered in a technology enhanced learning environment in the IBDP. It responds to research question 2 in this study. This survey question was completed by 79 participants.

The quantitative (Appendix C-Table 6) and qualitative data in this section reveal key concerns related to the implementation of personalised and autonomous learning opportunities in the IBDP during online teaching. The findings demonstrate teachers generally agreed to offer opportunities for personalised learning experiences for learners and to incorporate online tools that enable learners to access content and learn at their own pace. The response around opportunities for learners to be self-directed through flexible curricular choices reflects diverse perspectives. Similar diversity was notable in response to incorporating variety in the design of assessments, to provide individualised support to learners with varying learning needs reflect mixed responses. This diversity in the responses suggest issues and lack of clear strategies to approach personalisation in learning during this period though teachers shared several ways to extend support to students.

Some teachers shared that they gave text, videos, or different ways of presenting an idea once a week to incorporate some individual focus on the learners but the response rate to these tasks were poor during online teaching. Likewise, few teachers expressed their inability to plan differentiated tasks online due to large groups of students and some responses in the interviews did not provide clarity on the approaches used by the teachers. Another teacher admitted that they could not implement any differentiation due to technical difficulties, lack of familiarity with the digital platforms and student engagement issues online. The comments below further elucidate the issues experienced by IBDP teachers and administrators.

Talking about differentiated learning with 15 or 16 students online it's difficult to recognise who is paying attention and who's not..... I mostly used Google doc form or just an activity which is planned where we can see everyone's response or we just use a pad let, where I can see that students write their opinions or I just give them some article and ask them to describe it as per the content discussed.....

Personalising and independent learning.....I would have done it in a physical class that did not happen as much during the online teaching phase. online when I have 12-20 students in a class.....I am unable to do it separately from others.

It is challenging to create online different assessments with differentiated instructions and to monitor many students in the class doing different assessments at the same time.

Hence, differentiation based on content, skills and assessments was obstructed due to contextual and personal challenges encountered by the teachers.

4.1.5. This section presents findings deliberating on the implications of the emerging technologies for shaping the learning environments in International Baccalaureate schools in

future. It responds to research question 3 in this study. This survey question was completed by 79 participants.

The responses in this section involved to some extent, a form of crystal ball gazing or peeking into the future experience. The findings reveal recognition and a clear understanding of the need for technology-based teaching in the IBDP. The analysis of the findings elucidates different visualisations of the teachers for incorporating technology in future some of which include a hybrid model of teaching, virtual reality models and more extensive digital applications in science subjects.

Interestingly, some teachers endorsed strong support for the traditional face-to-face teaching format as well. Furthermore, the findings demonstrate a definite need to establish an organisational approach to bring a shift in the mindset of the teachers for adaptation of technology in future. The findings identify the emerging professional development needs to enable the teachers to adopt different digital technology applications and to equip them with skills and new ways of teaching and learning. The comments below encapsulate the views of teachers on ways they envision the role of digital technology in teaching and learning in the IBDP in future.

In future, I visualise it should not be 100 per cent online. It should be 50-50 in my opinion. It is comfortable for students also if we do 50 per cent online and 50 per cent face to face.

The future might be like this.... we might be living in Virtual Reality (VR), all our lives will be different in the VR world however, we all will be more connected.

It requires a change for the whole organisation, which includes strategies for professional development as an important agenda for adaptation of technology for the future.

I think the face-to-face method of teaching is more effective as compared to online, in my opinion, I will still love to see my students in person, to see their expressions and that experience is different that I cannot feel in front of the camera. So, I will prefer to go to a face-to-face classroom.

The school management must consider providing all sort of digital resources to facilitate online teaching for instance in Arts, I should have a different high-resolution camera attached to my screen to enable me to explain the concepts effortlessly without wasting time, good voice recorder,the first step is to provide a digital infrastructure that supports online teaching and help in setting up the tasks effectively. In my view, every school should think to acquire different types of new technology to support teaching and learning in future.

These views illustrate the central role of digital technology in teaching and learning in future. It also draws attention to a system-wide approach that includes a shared vision, organisational culture, and consistent processes to address this growing capacity of digital technology in the learning environments in future.

As the pandemic continues to impact the learning environments, hybrid or online teaching remains the way forward in several educational contexts. However, the lack of digital competence and readiness of teachers limits the ability to effectively navigate online teaching in several contexts. The findings derived in Study A encapsulate the challenges encountered by the teachers and a significant need for schools to develop a strategic professional development plan with a focus on developing the digital competencies of the teacher to

facilitate the transition to the digital world. These challenges are interrelated to well-being, content delivery and digital infrastructural issues which have been elucidated in this report.

4.2. Emerging Themes from Study A

An analysis of the survey data including the open-ended comments, together with the follow-up online interviews in Study A led to the development of themes that are identified and discussed below.

Table A: Themes Emerging from Study A

1. Transition to Online Teaching	2. Online Curriculum Delivery	3. Online Assessments	4. Miscellaneous Themes
<ul style="list-style-type: none"> Organisational support and focus Digital Transformation Digital Infrastructure Digital learning environment Digital resources Digital Readiness of teachers Professional Development Well-Being 	<ul style="list-style-type: none"> New pedagogical approaches Digital Content Subject specific content delivery Pace of learning Differentiation Personalised Support Autonomous learning Student Engagement Student Motivation 	<ul style="list-style-type: none"> Designing Assessments Internal assessments Online Monitoring Academic Honesty Student Feedback on teaching and learning 	<ul style="list-style-type: none"> Parental/community perspectives Budget/financial constraints Social interaction Student attendance Time management Online classroom management and class sizes Communication Collaboration and group work

The themes arising from the findings identify key issues related to the sudden transition to online teaching due to the pandemic in the IBDP schools, the impact of digital technology on curriculum delivery and the design and conduct of assessments online.

These themes have been elucidated further in the discussion section later in this report.

The next section presents the results of the data collected for Study B.

4.3. Study B

Study B involved the implementation of an AI application in the teaching of mathematics at the secondary school level. This case study was conducted while the school was following a hybrid model of teaching due to the pandemic. The study aimed to collect perspectives of students and mathematics teacher on the use of AI in teaching and learning, using an online survey with the students and was followed by individual online interviews with the students and teacher.

The participants in this case study were from an international (IB) school in the UK. They were from two different grade levels based on their availability and willingness to participate. There were in total 6 students who participated in this study, 3 core level mathematics students from

grade 9, 3 higher-level mathematics students from grade 11- IB Diploma Programme and a mathematics teacher.

The core level students were those with a basic level of mathematical knowledge and skills, who needed further support in strengthening this area. The higher-level IB students were those who were proficient in the subject and exhibited good knowledge and understanding of mathematics.

4.3.1. The findings in this section elucidate students' and teacher views regarding the influence of AI application on pedagogy and assessment. It addresses the research question 1 in this study.

The quantitative and qualitative findings reveal most respondents agreed that the AI application offered a wide range of learning resources, well-designed learning tasks, opportunities for increased engagement with the learning tasks, opportunities for learners to be self-directed through individual learning path, and opportunities for personalised learning experience which consequently offered them individual support in planning their learning activities. Data derived demonstrates a mixed response around AI application providing clear instructions related to learning activities. A further diversity in views was indicated in relation to full technical support, easy access to learning modules, help to organise learning independently, self-paced learning opportunities and collaborative learning opportunities with the peers. This was further corroborated through the open-ended comments in the survey. The findings suggest that students found the use of AI in learning catered to their individual level and helped them in revisiting and improving concepts that they had not reviewed for a long time. A few of them found time management and the mastery test quite difficult. The diversity in views was further investigated during the follow up interviews to identify individual preferences, learning behaviour and personal challenges of the students that impacted learning.

The quantitative and qualitative findings demonstrate that both groups of students (grades 9 and 11, IBDP) largely agreed that the AI application enabled them to understand the subject-specific content with confidence, to understand complex concepts through practice, actively engage in the learning process, practice a range of topics at their own pace and based on their individual abilities, and access learning tasks based on individual skills. The findings also reveal that learning tasks offered by AI was of high quality and provided an in-depth explanation of the subject related concepts. The questions related to the tasks were very different from each other but similar to what students saw during the classroom assessments. The practice tasks became progressively harder which catered to the individual ability of the students and consequently motivated them to work on the challenging areas in mathematics.

Hence the findings suggest the design of the AI offered a conducive and high-quality digital learning environment and consistent pedagogical support to students and teacher in the delivery of mathematics curriculum. Consequently, this resulted in enhanced engagement in the learning tasks, additional practice, and more self-directed learning initiatives amongst the students. Furthermore, conversations with the students reveal that AI application was accessible and provided individualised support during the preparation of a test or while reviewing the topic for additional practice in the absence of a teacher which improved their subject specific skills. Consequently, it took stress off and positively impacted students' confidence levels in mathematics that later ensued in improved academic performance.

The mathematics teacher expressed that the use of AI application helped to support students in their individual practice of topics. Hence when the student identified that they have a topic to further improve on and need additional practice they were able to do it more independently with the help of the AI application. This left free time for the teacher in the lessons to

concentrate on other aspects of teaching and administrative tasks. The comments below encapsulate experiences of students and the mathematics teacher. The student group expressed:

Well, the application showed me that when I don't understand something I don't just give up. It made me understand that math can be made easy if I practice, have the right questions, the right explanation and feedback. For example, I wasn't that good at probabilities but that's where the application helped me to do these equations and become better over time. So, it helped me a lot in understanding and interpreting questions during my class tests.

I think the AI application is quite specific in designing the practice questions which helped me in understanding subject concepts and I was able to get through everything in the actual subject in school

So, after I did the introductory test which tested my Maths level, it gave me topics to work which were supported with videos and detailed explanations followed by practice examples and questions to solve. Once I had finished all the topics it would give me more material for practice in other areas which I found useful.

The concept of complex numbers was a bit tricky for me, while I was learning it in school..... I then decided to use the AI application and watched the tutorial. I followed the video steps to the questions that I was doing for homework. I then attempted the practice questions offered by the AI application and those helped me with real specifics in broadly understanding the whole topic.

The mathematics teacher echoes similar views.

I watched some of the students complete the diagnostic test in the class and it does go from simpler questions to more difficult. There were 40 questions in total, but it was different for every student and seeing that process was interesting. The students have more ownership of what they are learning than just relying on me. It has made them more responsible for their learning.

For me as a teacher, it helps to diagnose what it is that students need to practice and give them that practice which if I try to do myself would take me a long time. So, it has helped me to personalise what every student need in my subject.

These findings demonstrate that largely both groups of students (grades 9 & 11, IBDP) felt that the quality of content and practice questions further supported the classroom learning and offered tiered support. The learning experience may be summarised based on students and teacher views and experiences. The students' views reveal enhanced learning experiences due to diagnostic test, quality of the content and pedagogical support offered by the AI application. The findings indicate that students found diagnostic assessment feature supported them in identifying their learning gaps, planning individual learning activities based on the identified strengths and weaknesses and offered a tiered support which subsequently helped in strengthening subject specific skills. The students further expressed that AI application extended personalised support, additional practice tasks and revision assistance on individual learning needs. They could access the application for revision purposes in the absence of the subject teacher which subsequently enhanced their confidence and relieved stress. The quality of the content and the practice tasks helped students in managing their learning independently.

The mathematics teacher elaborated on the experiences and shared that the administrator's dashboard offered an effective overview of student learning and clear indicators of time spent

on the activities created by the learning path. The diagnostic assessment further supported the teacher in scaffolding learning for individual students based on their abilities. The exportable reports at regular intervals provided prompt progress reports on the concepts and subject-specific skills and helped the teacher in monitoring students as well as having on going evidence of academic performance of each student. Consequently, the implementation of the AI application addressed some of the time management issues and provided teacher free time in the lessons to concentrate on other aspects of teaching. The teacher expressed that this experience led to students having more ownership of their learning.

Likewise, the findings demonstrate students largely agreed that the use of the AI application enabled them to understand subject-specific strengths and weaknesses, continuously reflect on the feedback, engage in self-assessment, gain a wider range of subject skills, monitor their learning, and enhanced self-confidence and ownership of learning. However, the aspect related to feedback reflects a distinct diversity in the responses. The students reported that they had received immediate feedback on their learning which served as a motivation to move to the next level and continuously reflect on their learning. Those who used it for a significant period reported that they strengthened the weak subject concepts which helped in increasing their self-confidence and improving the subject grades. Therefore, the findings related to the feedback stimulated a mixed response: both the groups of students agreed that feedback was prompt and indicated what was right or wrong. Moreover, responses reveal the feedback did not explain which step in the computation was wrong. Hence, the students were made to repeat the practice task till they get it right which makes the process automated and does not offer detailed feedback on the computational errors.

Conversations with the mathematics teacher reflect that the design and structure of the AI application provided overview of each students learning. It allowed access to the teacher to download the usage reports which indicated students' participation in different learning tasks, gave insights in the areas and concepts where students needed more support. The teacher further acknowledged that the AI application enabled to monitor the test which helped the teacher in providing intervention at various points and resolve the misconceptions of the students, if any.

The teacher summarised the feedback and monitoring process in the following words.

I think the feedback was more useful to me as a teacher than it was to students. The students just got 80% and the application would not guide them in what they did wrong. The thing with the AI application is that it does not pick up the nuances, mistakes students are making or a misconception that they have. It just tells them what is right or wrong and they need to practice it further.

Having the students locked out of a quiz when they score a certain grade and then the application does force the teacher to talk to the student to understand the difficulty and then to unlock the quiz. It was a good idea and I liked it because it does put more checks and balances with students. So, it did enable me to then unlock it after clarifying the conceptual difficulty to the students.

Similar views were expressed by a student.

It did help me in gaining confidence in correcting problems, before using the AI application, I would not be so sure if I'm doing this right or wrong but when I used the AI application it gave answers immediately and it made me more confident.

The findings further specify that students received instant feedback while using AI application which added to their confidence level. However, the application lacked in explaining the

computational errors. Additionally, if the students did not get a response right after certain attempts the application got locked and needed teachers' intervention to proceed further in the learning process. These findings also indicate that complex subject concepts needed teacher intervention which, as expressed above, supported the teacher in monitoring the learning. The feedback function further allowed the teacher to download the usage report which indicated how often the application was utilised by a student to gain support in learning. It also gave the teacher an understanding of the areas and concepts where students needed human intervention.

4.3.2: This section presents findings regarding independent and personalised learning opportunities for students while they used the AI application. It responds to research question 2 in this study.

The quantitative and qualitative findings reveal both student groups (grades 9 & 11, IBDP) concurred that the individual learning path created by the AI application was effective in offering personalised support as per the ability of each student. Both groups reported that additional practice offered by the AI application strengthened foundational subject skills, helped in revision, improved grades, and enhanced the self-confidence of the participating students. The application offered a diagnostic assessment for the participating students which created a comprehensive profile of their individual strengths and areas for improvement in mathematics. The application enabled students to understand the subject-specific content with confidence, to understand complex concepts through practice, actively engage in the learning process, practise a range of topics at their own pace and based on their individual abilities, and access learning tasks based on individual skills. Subsequently, this resulted in enhanced engagement in the learning tasks, and more self-directed learning initiatives amongst the students. The findings reflect that the design and development of the activities offered by the AI application offered distinct opportunities for independent and personalised learning to the students. These views and experiences from the quantitative data were further explored in depth through the qualitative interviews. The comment below elucidates mathematics teacher views.

For me as a teacher, it helps to diagnose what is it that students need to practice and give them that practice which if I try to do myself would take me a long time. So, it has helped me to personalise what every student means and it could be done by the AI application.

The comments below represent similar views of students.

It gave me quite a bit of support in mathematics as it identified my level of mathematics and I used it to gain information on the learning gaps. For example, it explained things in an alternate way than the teacher and I could understand better which gave me confidence.

I will say that it is good in a situation where you don't have a teacher and you need help with something quickly. Let's say for a test, I needed some quick revision, I would go to the application as it explains the topic quickly. Though it's way better to have a teacher to help you but the application is a good alternative if you ask me.

Well, AI application helped me to be more consistent in doing maths and it was quite interesting because when I wouldn't get something correct the application would give me easier questions to answer and build my way up. This helped me really understand the topic.

I think it pushed me to take the time and responsibility of learning into my own hands and that helped with my organisational aspect. I used the videos in the resource section to take notes and to practice the examples so when I did the practice questions, I had a clear understanding of what to refer to. It helped me with the areas that I was probably unaware that I was forgetting slowly, so it has reinforced my understanding of those.

I think it has helped me immensely and I was using it a lot. It's quite encouraging when you do the tasks designed as per your abilities, I could see my learning and progress so I think that was quite helpful as well. If I had carried on for longer it would have shown even more improvement in my mathematical skills.

To summarise, the findings in this section demonstrate that the application offered distinct opportunities for personalised and independent learning. The findings further indicate high level of student motivation and engagement in the activities offered by the AI application. The learning tasks and activities offered by the application offered user friendly material which was easily accessed and comprehended by the students involved in using the application which subsequently enhanced their confidence levels and improved their organisational skills. The application offered personalised support and offered an individual learning path for each student based on their abilities. It helped the students in identifying the learning gaps themselves and follow the practice questions to attain proficiency on a particular topic. This consequently aided students in becoming more responsible for their learning. The personalised support offered by the application was also found effective in scenarios where the teacher was not available to students for instance, clarifying a concept before a test or an exam which the application performed quickly. As expressed by the students, this sort of learning support relieved them of stress and other concerns impacting their well-being.

4.3.3. This section presents findings regarding *the implications of the emerging technologies for shaping the learning environments in International Baccalaureate schools in future.*

It addresses the research question 3 in this study. Data derived in this section contributes towards understanding the potential benefits of AI in teaching and learning.

The mathematics teacher reported distinct benefits witnessed in teaching, the AI application provided individually designed tasks which helped the teacher in differentiating the learning activities without investing time in physically designing separate tasks for each student. The findings also elucidate the vital role of diagnostic assessment in the learning process. It not only gave an overview of each student's learning but also distinctly facilitated scaffolding which is an interesting and promising area for supporting teaching and learning practices.

Conversations with the teacher reflect that the AI application facilitated effective monitoring processes. The application provided an overview of each students' academic progress with a summary of time spent using the application which kept the teacher well informed about individual progress of the students. The teacher acknowledged the usefulness of the application in enhancing the confidence level of students and consequently their academic progress. Further elaborating on the future implementation of the AI applications in teaching and learning the teacher stated:

Trialling it regularly in school settings and then having it for more subjects for lots of topics as well and developing it as a 'one-stop' location will be better but I think that's not going to happen so soon, so it's going to take quite a while to get unified. It will always be a case where one AI system is better than another.

Views such as these indicate conducting regular trials and pilots in several subjects and settings will pave way for effective integration of emerging technologies like AI in different

learning environments in future. Whilst AI offers innumerable opportunities to support teaching and learning data reflects that human input continues to play a key role in the learning process. The mathematics teacher echoes similar views.

There is always room for a person because computers are not going to do everything and though AI has come a long way in the last few years, you need that human input on learning. The AI system is just a dumb machine as I often told the students it has done what someone has asked it to do.

Views such as the one above highlights the value of human intervention in the learning process and strongly dismiss the notion of AI technology superseding them. Data derived stresses to deliberate on ways to maximize human potential in teaching and learning. Conversations with the mathematics teacher illustrate the implications of AI in shaping the future learning environments. The perspectives of the teacher also accentuate the uncertainty that dominates the present educational landscape and the opportunities it presents alongside. The new emerging technologies like Learning Analytics and AI carry the potential to benefit teaching and learning in educational settings however, it needs careful consideration and nuanced discussions regarding its implication on different subjects, age groups and learning environments. Additionally, it requires regular trials to evaluate the assistance and limitations of human-machine interactions in different learning environments.

Qualitative data in this study was organised in an excel sheet to identify recurring themes and pattern using thematic analysis by Braun & Clarke (2006). Initial codes were assigned to recurring ideas and concepts that were grouped together leading to the development of the emerging themes from this study. The data were organised into themes to further elucidate the clusters of meaning identified in the data set. Organising the data into separate themes is the process of reduction and interpretation of the data which allows the reader to see a clear structure to the data. This involved a process of drawing the themes together, considering how they respond to the research questions in this study and how they relate to literature in the field (Braun & Clarke, 2006).

4.4. Emerging themes from Study B

An analysis of the survey data including the open-ended comments, together with the follow-up online interviews in Study B represent the themes and associated codes that are discussed below.

Table B: Themes Emerging from Study B

1. Personalised Learning Support	2. Learning Experience	3. Student Engagement	4. Student Motivation
<ul style="list-style-type: none"> • Individual learning paths • Additional practice • Revision assistance • Overview of student learning • Monitoring learning activities 	<ul style="list-style-type: none"> • Scaffolding learning • Diagnostic Test • Conceptual understanding • Foundational subject skills • Ongoing assessment • Immediate feedback 	<ul style="list-style-type: none"> • Time management • Alternate way of practising and understanding • Human input on learning 	<ul style="list-style-type: none"> • Improved grades • Enhanced Self-Confidence • Reduced Stress • Ownership of Learning

The findings from the data indicate the potential role of AI mediation in the teaching and learning of mathematics. Students derived benefit from the personalised support which includes individual tiered support, additional practice, and revision assistance. Since AI is a burgeoning area of research, its application carries the potential to benefit teaching and learning in educational settings however, it needs careful consideration and nuanced discussions regarding its implication on different subjects, age groups and learning environments. The findings and points for consideration emerging from this case study are based on respondents' views and use of a specific commercially designed AI application. Hence, the challenges identified around feedback may be addressed by another application as this burgeoning field of research continues to develop. These themes have been further discussed in the next section.

5. Discussion

The research findings in the previous section elucidates emerging themes from both Studies A and B. These emerging themes present patterns, concepts, observations, connections, and characteristics recognised from the data sets. There are three major themes emerging from Study A, they are: *Transition to online teaching, Online curriculum delivery and Online assessments* whilst Study B presents four major themes emerging from the findings, they are: *Personalised learning support, Learning experience, Student engagement and Student motivation*.

To present a more enriched and nuanced understanding of the issues identified in this research, this section was developed by interpreting the emerging themes and their links to concepts and ideas emerging from the literature. The section leads to proposed strategies for incorporating the emerging technologies in the context of IBDP.

5.1. Discussion and links to the themes emerging from Study A

Study A elucidates the views and experiences of the IB Diploma Programme teachers and coordinators about the use of digital technology during online teaching due to the COVID-19 pandemic.

The first theme from Study A is *Transition to online teaching*, it elucidates a range of issues concerning organisational support and focus, digital transformation, digital infrastructure, digital learning environment, digital resources, digital readiness of teachers, professional development, well-being, hybrid learning, blended learning. This theme responds to Research Question 1 and Research Objective 1.1.

The findings provide rich accounts of the experiences of the IBDP teachers during the transition and are further contextualised by the literature. This theme *Transition to online teaching* captures the views and experiences of the IBDP teachers and coordinators on the use of digital technology in teaching and learning during the COVID-19. The school closure due to the pandemic in early 2020, caused severe disruption in teaching and led to a major shift to the remote learning environment (UNESCO, 2020a). Schools, educators, students, and policymakers were compelled to adopt new ways of teaching and learning almost overnight without much planning preparation and in few cases digital experience (Kamanetz 2020; Sun et al., 2020). This swift change from a physical classroom to an online learning environment had a distinct impact on the use of digital technology in a school setting (Patel et al., 2020) stressing the need for teachers and students to adapt to new technology platforms for learning (Education Endowment Foundation, 2020; UNESCO, 2020c).

The theme reveals IBDP teachers and coordinators' perspectives about the organisational support and digital infrastructure that stresses issues concerning access to the internet by

students and teachers, adequate digital resources and technology tools, and inconsistent learning management systems used across schools. It emerged that the transition issues related to online teaching were more pronounced in schools that lacked regular use of digital technology before the pandemic whilst schools that had incorporated digital technology could transit swiftly to online teaching since students had access to the internet and devices (Petrie et al., 2020). The responses related to access to digital infrastructure and learning management platforms encapsulate a range of diverse experiences of the teachers that stress the individual context. Whilst in some regions of the world teachers felt constrained due to a lack of access to a stable internet connection, devices, digital resources, and organisational support in the transition to online teaching. In some contexts, the cost of providing mobile data was exceptionally high and only a few students had computers and laptops at home which obstructed the online delivery during lockdown due to the global pandemic. The literature (OECD, 2020; Zhao 2020; Bubb and Jones, 2020) concurs on similar transitioning challenges encountered by educators and school leaders across the world which validates these issues and concerns.

Several such contextual challenges about access to digital infrastructure and resources indicate a persistent digital divide that has further widened during the global pandemic due to contextual barriers in school settings (United Nations, 2020). Moreover, the findings elucidate teachers' concerns over several abrupt changes to try different technology platforms and learning management systems by their schools that added to the stress during the transition to online teaching (Comanducci, 2020). Additionally, Study A goes on to elaborate on a set of issues pertaining to the IBDP, for instance, teachers and administrators in some IBDP schools had undertaken extra efforts to recreate a similar learning environment online as the students had in a physical classroom due to parental demands and insistence. This implied that the schools procured whiteboards for teaching and extra cameras during the lockdown were installed at the teachers' residences to create a classroom environment though there were technical alternatives the parents refused to accept them. Consequently, this caused additional challenges and had financial implications for the school in a period of uncertainty and turmoil. Besides, the stakeholders in certain contexts disregarded the online teaching approach that added to the difficulties of teachers and coordinators during this transition.

The findings further reveal the dilemmas and challenges faced by the school leaders (in this study IBDP coordinators) who felt constrained in handling this sudden transition and the nature of the challenge varied from those experienced by the teachers. Managing the change at the organisational level involved ensuring online schedules were created, adequate online environments were identified, school managements or Ministry of Education requirements were considered, and the expectations of parents and students were managed satisfactorily. Along with the administrative requirements, it involved ensuring the well-being and motivation of staff and students. The findings further revealed that school leaders, felt immensely pressured by the stakeholders in terms of the design and delivery of online teaching. It emerged from the findings that in certain contexts Ministry of Education, school management and the parents had very specific expectations for the delivery of online teaching which restricted the school leaders and added to the transition challenges. Consequently, this raised several well-being concerns as teachers were overburdened and exhausted with arduous teaching schedules including extended working hours and additional working days to meet the expectations of the stakeholders in several schools.

Besides, the school leaders expressed that they also had the additional responsibility of monitoring the curriculum delivery and ensuring the ongoing professional development of the teachers. Implementing all this at an organisational level required a system-wide approach which was lacking and consequently made this transition extremely challenging. The published literature corresponds with some of these views, school leaders were seen handling tasks beyond the scope of their defined roles to manage this crisis with limited resources in

most cases and were compelled to take swift decisions and initiate new processes overnight, guide and advise students, parents, and staff, and provide moral, social, and professional support to the stakeholders (Alevizou, 2020). It implies a need for a system-wide organisational approach that includes strategies for professional development as an important agenda for the adaptation of technology for the future. The findings also draw concerns towards the well-being of the school leaders, a subject that needs more focus and development. There is limited evidence of research studies capturing the challenges of the school leaders during the pandemic.

Additionally, across the data, the transitioning experiences and the personal challenges shared by the teachers elucidate a strong need for upskilling and ongoing professional development to enhance teachers' digital competencies. Not all participants viewed themselves as well equipped or trained in strategies that could help them to transit to an online teaching environment. Therefore, the findings elucidate a mixed response about professional development support during the pandemic owing to contextual difficulties, strategic support from the school leadership and the personal circumstances of the individual teacher. Whilst some teachers expressed to have received ongoing upskilling in their settings, others were left to find their way and manage the crisis on their own. Consequently, these issues impacted the well-being of the teachers and students which emerged as a significant concern during this study. The findings demonstrate teachers were exhausted due to prolonged screen timings, long working schedules, online meetings with students and school leadership after school hours, fear, anxiety, and personal loss caused due to the pandemic. Similar issues were reported regarding students' behaviour that impacted the engagement and motivation levels of students during online teaching. Furthermore, most teachers and administrators reported reducing the teaching timings to facilitate online teaching effectively which consequently impacted the curriculum delivery. Hence, the issues arising from this research reveal an interesting pattern and draw a correlation between the themes in Study A and the transition issues which overlapped with several aspects of online curriculum delivery and assessments. At several places, the teachers could not detail their transitioning experiences without mentioning the challenges about online content delivery and assessments.

These transition issues had a considerable influence on the curriculum delivery and several aspects associated with it that are elaborated in theme 2.

The second theme from Study A is *Online Curriculum Delivery*, it elucidates the impact of this sudden change on several aspects of curriculum delivery that includes new pedagogical approaches, digital content, subject specific content delivery, pace of learning, differentiation, personalised support, autonomous learning, student engagement, and student motivation. This theme responds to research questions 1 and 2.

This theme brings together the accounts of IBDP teachers and coordinators on the impact of the sudden shift to online teaching on several aspects of curriculum delivery during the pandemic. Most teachers expressed that they would prefer face-to-face teaching as they were not satisfied with the way content was delivered digitally. The teachers generally found it challenging to develop digital content and relied on common internet websites and YouTube resources. They reported using a lot of tutorials, notes, animations, and simulations that were available on the internet and all these resources also helped the students. Teachers expressed difficulties while creating the digital teaching resources to complement the subject specific content like videos and worksheets which was time-consuming and made the online content delivery challenging. They recognised their struggles in identifying alternate ways to incorporate digital lessons to help the students. On the contrary, the schools with established digital repositories or platforms for digital resources found online content delivery imposed no difficulties on their teachers. In some contexts, teachers expressed concerns regarding the lack of flexibility in organising online lesson delivery. They reported to have been directed to

conduct all the lessons online than having the flexibility to hold some lessons asynchronously and allow students to manage their screen time in smaller chunks. Views such these reveal contextual challenges, policies, and approaches by different schools to organise online learning.

Moreover, the findings demonstrate that most schools were unprepared to deal with this massive shift to online teaching and learning. Conversations with the teachers and coordinators reveal Internal assessments (IA) and Extended Essays (EE) components in the IBDP posed the greatest challenge due to the lack of organised digital resources to support the process. Some teachers expressed that they only had access to free resources and the school did not subscribe to other online tools and resources which constrained the delivery of these components. In many cases, online teaching was used as a substitute for offline learning and not as an efficient alternative. The teachers shared using the same pedagogical approaches which they used offline while teaching online too, some of them shared they replicated the same timetable and teaching strategies and realised that it does not work in the online environment. This indicates that teachers need more clarity and training on how digital technology may be deployed more efficiently.

These findings elucidate difficulties associated with the nature of the different subjects in the DP, availability of technology tools, teachers' readiness to adapt those tools and contextual difficulties about the availability of subject-specific resources. It expands difficulties around online student engagement, an area that draws significant focus during online teaching. Similar challenges have been reported in the COVID Research Project by the teachers. UNESCO's report titled, *Education in a post COVID world Nine ideas for public action* acknowledges the weaknesses and challenges elucidated during COVID 19. It states, "Curricula should be increasingly integrated and based on the themes and problems that allow us to live in peace with our common humanity and our common planet" (UNESCO, 2020b), these views resonate with the broader aims of the IB education.

Notwithstanding the challenges, the findings also reflect some positives during the sudden migration to online teaching which paved way for new pedagogical approaches and creative ways to address online curriculum delivery. The pandemic highlighted unparalleled opportunities to collaborate and co-create experiences using new technologies as stakeholders (Doucet et al., 2020). Interestingly, teachers shared creative ways used by the students in redesigning approaches to a learning task to meet the resource requirement during the lockdown. An IBDP Visual Arts teacher echoes similar views.

The students tried to explore new ideas and come up with innovative ways to approach the content..... for example, an Indian student completed her studio work painting with Haldi (turmeric), honey and coffee at home during the lockdown as getting the art material and supply is very difficult in our region.

This allowed learners to develop an understanding of what they want to learn, and the support needed in the process of learning. Responses such as this, echo the idea that innovation and creativity are not exclusively meant for well-resourced schools and organisations rather the potential for transformation is a broad effort from all the stakeholders-teachers, students, and communities (UNESCO, 2020b).

Furthermore, teachers expressed differentiated instruction as an area of significant challenge that needs more pedagogic support while delivering the curriculum online. It requires a variety of strategies and practices other than break out rooms and specific study material. The findings reveal several challenges in creating study material for differentiated learning, maintaining a learner portfolio for differentiation, identifying differentiated instruction and assessment tools for the IBDP. Moreover, the quantitative responses indicate a disagreement

concerning opportunities for learners to be self-directed through flexible curricular choices, drawing attention to a significant issue that impacted teaching and learning. The findings reflect several issues that influenced autonomous learning including lack of access to the internet and digital infrastructure which influenced student engagement and student motivation issues. The findings also reveal specific concerns about low engagement from pupils with limited access to IT resources or those who lacked space to study at home in certain contexts. The findings also highlight concerns around students with inclusive requirements. Some other issues include online monitoring learners and maintaining learners' portfolios, the well-being of students, personal challenges, and the professional development needs of the teachers. Additionally, the lack of social interaction-the social aspect of learning was something missed equally by students and teachers during the online teaching.

Teachers and coordinators shared several aspects that need specific pedagogic support to incorporate digital technology effectively in the IBDP, which include access to quality content and more subject-specific resources, explaining content and extended concepts to students in an online environment, student-friendly instructional aids, online assessment tools for the IBDP teachers, collaboration, and group work for students. Lack of collaborative time for teachers during online teaching has emerged as a notable concern, school ran with very less or reduced collaborative time, which needs redressal to extend pedagogical support. Likewise, findings indicate the need for more research and investigation related work and formal training opportunities for the teachers in the IBDP. Teachers and coordinators suggested a more flexible curriculum at the DP level might ease the pressure on the teachers.

The issues concerning the online delivery of curriculum closely impacted the design and conduct of assessments in an online environment which is addressed by the next theme.

The third theme from Study A is Online Assessments which includes designing assessments, internal assessments, online monitoring, academic honesty, and student feedback on teaching and learning. This theme responds to research questions 1 and 2.

It emerged from the findings that most teachers agreed to be able to explain learning objectives and goals efficiently, to implement interactive assessments in their subject, to implement efficient submission, marking, moderation and data storage in their subject and to use an assessment process to inform and align their teaching practices. Similar diversity in responses emerged around variety in the designing of assessments, for example, interactive online tests that facilitate learner-led formative assessments and incorporating online tools that enable learners to self-assess their work. Also, similar diversity was reflected to conduct pre-assessment in a variety of ways for building on learners' prior knowledge. Therefore, it stands out as a prominent concern that needs further consideration.

Likewise, the findings reveal distinct challenges around the designing of online assessments both in terms of quality, clarity, and content in the IBDP. For instance, most schools indicated using Assess prep or exam net where these issues were experienced by the teachers. However, these platforms did not cater to the requirements of students with learning challenges which made it difficult to implement an inclusive approach and differentiation in assessment. Given these challenges, teachers shared designing short assessments using MS forms or IB question banks which simplified the design of the assessment and consequently also simplified the content which implies quality of assessments was significantly compromised during the online teaching. Also, the preparation of multiple-choice questions reflects diversity in views which may be contributed to the nature of different subjects. Additionally, it emerged that teachers found it extremely challenging to create online assessments with differentiation and to monitor many students in the class doing different assessments at the same time. Similarly, during the oral examination, it was difficult to get introverted students to speak online. Hence, the teachers found conducting the oral

examinations not as effective in an online environment as they could not address all the required skills of the subjects.

The published literature further corresponds with the findings in this study. It identifies immense challenges about the design and conduct of assessments which faced several trials and errors. There was a lack of clarity and unpreparedness amongst organisations and educators to address this issue. The sudden lockdown and school closure not only impacted the internal assessment but also public examinations like the General Certificate of Secondary Education (GCSE). The possibility of postponement or cancellation of the entire examination depending upon the length of lockdown was indicated (United Nations, 2020). Another area of challenge was concerning authentic assessments and timely feedback which forms an important aspect of learning. The educators and schools reported prominent challenges in conducting formative assessments and providing timely feedback to students during online teaching (Doucet et al., 2020).

These findings stress on the requirement of incorporating tools like personal analytics to provide an accurate picture of student learning. This aspect reflects strong links with the discussions in Study B (presented in the next section of this chapter) where the use of AI has addressed such issues. Furthermore, these findings illuminate the need of incorporating more sophisticated digital applications to facilitate summative assessments. Some of these digital tools and applications have been endorsed by the published literature, for example, ALEKS (Craig et al., 2013), OLI learning course (Lovett et al., 2008), SQL-Tutor (Mitrovic & Ohlsson, 1999), Cognitive Tutor (Pane et al., 2014), and ASSISTments (Koedinger et al., 2010) cited in (Luckin & Cukurova, 2019). CENTURY Tech, Cognii, iReady, Edmentum, Cog Books, Summit Learning are some of the other popularly known AI applications in Education supporting learners and teachers in various aspect of learning. Additionally, the 8 Case Studies (Baker & Smith, 2019) discussed in Chapter 2 elaborate on the implications of the emerging technologies in supporting the assessments and marking procedures. Whilst the necessity and importance of integrating technology in the assessment process has been discussed and emphasised above, I concur with the views of authors like Draper (2009a), Draper (2009b), Boud & Molloy, (2013), and Hattie & Brown (2008) contend that innovations in assessment practices must be based on a 'pedagogically driven model that can allow students to take more control of their learning and become more reflective' (Whitelock and Watt, 2008, p.152), in place of considering new forms of assessment based on prospects of technological developments only.

Furthermore, the teachers expressed the way forward must be research-based and project-based assignments which would be helpful for the IBDP students. Moreover, teachers proposed increasing the weightage of internal assessment to stress ongoing evidence-based assessments, particularly in situations such as the pandemic. UNESCO (2020b) report titled, *Education in a post COVID world Nine ideas for public action* emphasises the importance of internet access and device connectivity and a strong need to bridge the digital divide in a post COVID world by prioritising open licensing and open access policies that support free use, reuse, repurposing, and adaption of digital technology. The report further stresses to ensure this digital transition is not driven by EdTech companies but includes relevant stakeholders such as teachers, students, governments, civil society, and privacy advocates to shape the educational transformations in a post COVID world (UNESCO, 2020b).

The next section deliberates discussion around the themes emerging from Study B which encapsulates the implementation of AI in a secondary school math class in an international school.

5.2. Discussion and links to the themes emerging from Study B

This case study was conducted while the school was following a hybrid model of teaching due to the pandemic. The study is set out to collect perspectives of students and mathematics teacher on the use of AI in teaching and learning. It involved the implementation of an AI application in the teaching of mathematics at the secondary school level. The application worked on the principles of adaptive learning that identifies students individual learning gaps and academic strengths with a focus on the progression of subject-specific skills. The initial diagnostic assessment aimed at identifying the subject-specific strengths and requirements of students, and this data was used by the application to offer targeted tiered support. The findings present the data that include students and teacher views and experiences on the implementation of AI. The following four major themes emerged from Study B that indicate ideas, patterns, connections and common characteristics to the issues discussed earlier in this chapter. These have been elaborated on below.

The first theme *Personalised Learning Support* includes issues related to individual learning paths, individualised support, additional practice, revision assistance, personalisation, overview of student learning, monitoring learning activities. The findings reflect, both student groups (Grades 9 & 11) concurred that the individual learning path was effective in offering personalised support as per the ability of each student. Both groups reported that additional practice offered by the AI application strengthened foundational subject skills, helped in revision, improved grades, and enhanced the self-confidence of the participating students. The AI application offered an adaptive diagnostic assessment for the participating students which created a comprehensive profile of their individual strengths and areas for improvement in mathematics.

Furthermore, while analysing the data in this study, I identified strong links with the themes emerging from Study A. Whilst the findings from Study A reflect a lack of individual help and personalised support as an emerging concern during the transition and implementation of online teaching due to the global pandemic, the findings and themes emerging from Study B endorsed the potential role of AI in addressing issues related to personalised learning and individualised support to learners. The published literature corresponds with the findings of Study B, some of the examples of other widely used Intelligent Tutoring systems for personalised instruction in learning are ALEKS (Craig et al., 2013), OLI learning course (Lovett et al., 2008), SQL-Tutor (Mitrovic & Ohlsson, 1999), Cognitive Tutor (Pane et al., 2014), and ASSISTments (Koedinger et al., 2010) cited in (Luckin & Cukurova, 2019). CENTURY an adaptive learning platform that identifies student strengths, weaknesses, and gaps in knowledge through diagnostic tests and formative assessment and structures appropriate support and scaffolding. This results in effective support to teachers as data analytics provide them insight into individual student's progress which in turn enables teachers to extend more effective and individualised support (Baker & Smith, 2019, p.11).

The themes and patterns emerging from Study B emphasise the vital role of diagnostic assessment which may help in creating individual portfolios and learning paths. Moreover, the findings reflect additional practice tasks and revision support which saves the time and efforts of the teachers who otherwise would have prepared it manually. As Luckin states, "The combination of big data and AI could provide learners with their own personal analytics, which they can leverage to become the most effective learner they can be (Luckin et al., 2016).

The second theme *Learning Experience* elucidates issues related to scaffolding learning, diagnostic test, conceptual understanding, foundational subject skills, ongoing assessment, immediate feedback. It emerges that respondents largely agreed that the AI application enabled them to understand the subject-specific content with confidence, to understand complex concepts through practice, actively engage in the learning process, practice a range

of topics at their own pace and based on their individual abilities, and access learning tasks based on individual skills. However, the responses reflected different levels of agreement about integrating real-life situations, setting personal learning goals and curiosity to learn new concepts.

The students expressed that learning tasks offered by AI were of high quality and provided an in-depth explanation of the subject related concepts. The questions related to the tasks were very different from each other but similar to what students see during the classroom assessments. The practice tasks became progressively harder which catered to the individual ability of the students and motivated them to work on the challenging areas in mathematics. It emerged that students largely agreed that the use of the AI application enabled them to understand subject-specific strengths and weaknesses, continuously reflect on the feedback, engage in self-assessment, gain a wider range of subject skills, continuously monitor their learning, and enhance self-confidence and ownership of learning. It emerged from the findings in Study B that students derived benefit from the personalised support which includes individual tiered support, additional practice, and revision assistance. As Luckin states, "It can be used to scaffold (support) learners to develop these key skills by reflecting across their personal data using carefully designed interfaces and visualisations, in this way all learners could be helped to be better at learning, which would be useful across all subject areas" (Dickson, 2017).

I observed these findings from Study B respond to several challenges identified in Study A, though generalising them would not be appropriate, however, one can draw on the findings from Study B to explore answers to some of the issues raised in Study A. The findings and emerging themes from Study A highlight the difficulties encountered by the teachers in facilitating conceptual understanding and subject-related concept knowledge in an online environment. These issues have shown a distinct impact on the teaching approaches, content delivery and quality of the curriculum delivery as discussed earlier in this chapter. Whilst the findings from Study B reflect that AI provides high-quality content for practice and further conceptual understanding in a specific subject.

The findings also reveal the vital role of diagnostic assessment in the learning process. It not only gave an overview of each student's learning but also distinctly facilitated scaffolding which is an interesting and promising area for supporting teaching and learning practices. In my experience as an IBDP educator, mostly the formative assessments are planned and structured by the teachers using a backward design to the summative tasks, where the emphasis is laid towards the preparation of an end term assessment which often restricts opportunities for students to participate in the ongoing assessment process. It emerged from the findings in Study A that student autonomy in the learning process resulted in enhanced participation and increased motivation levels. Similarly, findings from Study B reflect that the individual learning path created by the AI application facilitated ongoing assessments in an organic manner. Hence, it may be inferred from the findings that there is a distinct need to incorporate more ongoing and formative assessments due to changes arising in teaching and learning in view of a shift to digital learning environments. The published literature further concurs with the benefits of continuous assessments and ways in which AI applications offer opportunities for conducting more meaningful formative assessments. CENTURY has applied the principles of spaced learning to design the learning "nuggets" that focus on small topics of learning followed by a formative assessment. The principles of spaced learning stress information are acquired if it is delivered through short time slots and repeated multiple times providing a sufficient time gap between each attempt (Cepeda et al., 2006). Consequently, it is focused on improving learning outcomes and addressing the achievement gaps (Luckin & Cukurova, 2019). It may be inferred from the published literature that AI in Education may contribute towards innovating assessments. Elaborating on ways in which it may change the "How" of assessment, the NESTA report states that AIEd tools now enable automated marking for much more complicated questions and provide formative feedback to learners.

Consequently, it reduces and simplifies the human efforts needed to complete the marking tasks, addressing the issues around teachers' workload (Baker & Smith, 2019, p.41-42).

Furthermore, the students shared that they had received immediate feedback on their learning which served as a motivation to move to the next level and continuously reflect on their learning. Those who used it for a significant period noted that they strengthened the weak subject concepts which helped in increasing their self-confidence and improving their subject grades. The findings under this theme demonstrate that largely both groups of students felt that the quality of content and practice questions further supported classroom learning and offered tiered support. Though the questions regarding the feedback stimulated a mixed response: both the groups of students agreed that feedback was prompt and indicated what was right or wrong. However, the feedback did not explain which step in the computation was wrong. Hence, the students were made to repeat the practice task till they get it right which makes the process automated and does not offer detailed feedback on the computational errors.

The AI application helped in explaining the subject concepts with interesting videos and high-quality practice tasks. However, as the findings indicate complex subject concepts needed teacher intervention which subsequently also supported the teacher in monitoring student learning. The findings also emphasize the value of human input in the teaching and learning process. The AI application got locked after a certain number of incorrect attempts by the student and prompted teacher intervention. This kept the teacher informed of the learning difficulties encountered by the students and leveraged an opportunity for human input in the learning process. The published literature further reinforces the importance of human teachers and counters the common belief that AI is aimed to replace the teachers (Baker & Smith, 2019, p.12-13). As Luckin further explains: "It is educators who understand what is to be taught, how their students learn and what types of system are likely to work in the hustle and bustle of most educational environments" (Baker & Smith, 2019, p.33).

Likewise, the mathematics teacher reported another distinct benefit witnessed in teaching, the application provided individually designed tasks which helped the teacher in differentiating the learning activities without investing time in physically designing separate tasks for each student. Also, the published literature and case studies discussed in Chapter 2 concur with these findings elucidating the significant role and potential benefits of AI in Education. ALEKS (Craig et al., 2013), OLI learning course (Lovett et al., 2008), SQL-Tutor (Mitrovic & Ohlsson, 1999), Cognitive Tutor (Pane et al., 2014), and ASSISTments (Koedinger et al., 2010) cited in (Luckin & Cukurova, 2019). CENTURY Tech, Cognii, iReady, Edmentum, Cog Books, Summit Learning are some of the other popularly known AI applications in Education supporting learners and teachers in various aspect of learning.

Similarly, another interesting aspect that I observed during the analysis was a continuous cycle of inquiry, action, and reflection where the individual learning path created by the AI application nurtured this process and helped students in progressing independently which reinforces the IB philosophy and augments student-centred and student driven learning approaches. The findings in Study B demonstrate continuous monitoring support and clear ownership of learning by students which have emerged as a recurring concern during the online teaching phase in Study A.

The third theme *Student Engagement* includes issues related to time management, alternate way of practising and understanding, human input on learning. Some of the other themes emerging from the data indicate that prolonged and consistent engagement with the AI application resulted in enhancing self-confidence, improved scores in mathematics and reduced stress as reported by the students.

Furthermore, the published literature concurs with these findings and indicates that subsequently, this enables the learners to develop a self-learning, self-assessing behaviour which facilitates lifelong learning. According to Luckin, "Self-knowledge (knowing what you do and don't know) and self-regulation (for example, being able to stop yourself from being distracted by what someone else is doing) are two skills that such systems can help develop" (Dickson, 2017). The issues emerging in relation to time management were mostly related to finding more time to engage in additional practice with the AI application. Interestingly, the aspect of teacher intervention to explain complex concepts and unlock the quiz to facilitate further feedback highlights the ongoing need for human intervention in the learning process.

The fourth theme *Student Motivation* includes improved grades, enhanced self-confidence, reduced stress, ownership of learning. As reported by the participants in this study, the use of AI application not only improved the subject grades and led to reducing stress but also enhanced self-confidence which positively impacted the student motivation and engagement. The use of the application was self-paced which created opportunities for self-directed learning. I identified distinct connections between the issues discussed in Study A, and the patterns emerging from Study B. Student motivation and autonomous learning is reflected as one of the major issues in the two studies during the online teaching, the findings from Study B evidence that AI aided in strengthening conceptual knowledge by providing individual support and additional practice using a learning path resulted in enhanced self-confidence and improved performance. Consequently, the enhanced self-confidence, motivation, improved academic performance levels and reduced stress reflected positively on student well-being, an area of prominent concern as revealed in Study A.

The research findings and points for consideration emerging from this case study are based on respondents' views and use of a specific commercially designed AI application. Hence, the challenges identified around feedback may be addressed by another application as this burgeoning field of research continues to develop. The findings from this preliminary study may be used to further develop personalised learning experiences for students in other subject areas and the larger context of the school setting.

5.3. Summary of discussions

The previous section brought together discussions and links from the published literature and Studies A and B. These studies were conducted during the unprecedented pandemic which impacted the world in profound ways. The hallmark of this period is an unprecedented growth and reliance on digital technology and is also characterised by phenomenal changes in teaching and learning, which has been captured in this research through the perspectives of the teachers in IB schools. Research and conversations around online learning convey important shifts in ways digital technology will continue to play a significant role in education in future.

The pandemic and several national lockdowns worldwide also witnessed a large-scale reliance on learning management platforms, interactive digital learning environments, use of Intelligent Tutoring Systems and AI applications, to facilitate remote learning in international schools, their implications on teaching and learning have been elaborated further in this study. The pandemic highlighted unparalleled opportunities to collaborate and co-create experiences using new technologies as stakeholders (Doucet et al., 2020). The published literature further corresponds with the findings in this study. It identifies immense challenges about the design and conduct of assessments which faced several trials and errors. There was a lack of clarity and unpreparedness amongst organisations and educators to address this issue. The sudden lockdown and school closure not only impacted the internal assessment but also public examinations like the General Certificate of Secondary Education (GCSE). The possibility of postponement or cancellation of the entire examination depending upon the length of

lockdown was indicated (United Nations, 2020). Another area of significant challenge was concerning authentic assessments and timely feedback which forms an important aspect of learning. The educators and schools found it extremely difficult to conduct formative assessments and provide timely feedback to students during online teaching (Doucet et al., 2020). The findings reveal the requisite conditions for incorporating tools like personal analytics to provide an accurate picture of student learning. This reflects strong links with the discussions in Study B where the use of AI has addressed this issue. Furthermore, findings from this elucidate the need of incorporating more sophisticated digital applications to facilitate assessments.

Likewise, the discussions and findings from this research elucidate several key areas of focus which include access to digital infrastructure and resources, a renewed focus on technology-led pedagogical strategies and upskilling of the teachers, reviewing, and reforming the assessment and feedback practices. The aspect which emerged strongly from the findings is the need for autonomy in teaching and learning processes not only to facilitate innovation and creativity but also to further towards more personalised approaches in learning in future (UNESCO, 2020b). These factors need consideration by educators and school leaders to rethink changes in education in future to incorporate a curriculum that is developmental, personalised, pedagogy that is focused on student-centred and inquiry-based approaches, and delivery of instruction that uses both synchronous and asynchronous learning (Zhao & Watterston, 2021). A major challenge that emerged during the research is related to access, affordability, flexibility, pedagogy, lifelong learning, and educational policy (Murgatroid, 2020).

An IBDP administrator's views aptly encapsulate the way forward in the following words.

This pandemic has been a crucible experience for everyone, especially the teachers. Many were not comfortable using digital technology earlier, but they were left with no choice but to embrace this new normal. It has injected a fresh breath of air as the teaching methodologies that we were using pre-COVID have passed their sell-by date. It is taking time for our teachers to become technology-minded, but they have no other choice. They will become redundant and obsolete if they don't learn new and effective pedagogies to teach online.

Based on the findings from this research and the published literature, I have proposed several strategies that can be adopted in different domains in an international school context. Those have been discussed below.

6. Conclusion and Proposed Actions

The findings from Studies A and B aptly present the issues and dilemmas faced by the teachers and administrators in addressing the shift to the digital environment. The perspectives of the teachers also accentuate the uncertainty that dominates the present educational landscape and the opportunities it presents alongside. Based on this evidence, the published literature, and my own experience as an IB professional, I believe we are experiencing a redefining moment to rethink education and focus on the 'what, how, and where of learning' (Zhao, 2020).

From the data in Study A, I have identified ways in which digital technology influenced and changed the teaching practices and the underlying factors reported for these changes during the shift to online teaching due to the COVID-19 pandemic. The findings from Study B elucidate the role of new emerging technologies in this case AI and its potential benefit in teaching and learning. The implications of these changes on teaching and learning are manifold hence implementation of new digital technologies in educational settings require careful consideration and nuanced discussions. Additionally, it requires regular trials to

evaluate the assistance and limitations of human-machine interactions in different learning environments.

To summarise the implications of this study and in view of the changes reflected in the learning environments, I have proposed strategies that are grounded in the published literature and draw from the data gathered in this study. These strategies may be used as guidelines to create opportunities for integrating new digital technologies like Learning Analytics and AI to improve the quality and efficacy of the pedagogical design, promote an inclusive approach to learning, to support personalised feedback and critical reflection and demonstrate efficiency and transparency in teaching and learning processes. Though it was not a direct focus of this study, however, General Data Protection Regulation (GDPR) to handle the personal data of students and staff emerged as an important concern from this research. Therefore, the GDPR norms and ethical use of digital technologies must be factored in as a significant consideration for the learning environments in future.

The next section deliberates on ways the emerging technologies like Learning Analytics and AI can be integrated into the learning environments in future. I have proposed strategies to amplify the practical implications of this study. Based on the findings from this research and the published literature, I have proposed several strategies that can be adopted in different domains in an international school context. Furthermore, I have proposed strategies suggesting ways in which Learning Analytics and AI can be incorporated in the IB Diploma Programme using the Programme Standard and Practices Framework (2020). These have been discussed below.

6.1. Strategies for Educators, School Leaders, Policy, and Practice in International schools.

1. Pedagogical Strategies

Several issues regarding the pedagogical practices emerged from the findings in this study, following strategies propose incorporating Learning Analytics and AI to address some of those concerns.

- **An overview of Student Learning:** The implementation of Learning Analytics and AI in different subjects enables structured learning support for students as per their subject choices. The application then serves as a central platform for providing an overview of each student's learning by the concerned stakeholders.
- **Differentiated Instruction:** Differentiated instruction emerged as a prominent concern in this study. The COVID Research Project and Study A elucidate the challenges shared by the teachers in implementing differentiation in an online environment. Whilst the findings from Study B reflect that implementation of AI application supported the differentiated task for the teachers. The tasks were designed by the application based on the individual learning path of the student. This reduced the efforts of the teacher, saved time spent on creating additional worksheets and allowed taking the knowledge and understanding of the student to the next level. It also supported the teacher in scaffolding learning and providing personalised support to students. Hence, AI in Education (AIEd) can be used to formulate effective pedagogical strategies in supporting teachers in differentiation and providing personalised support an area that remains of significant concern in the online teaching environments.
- **Skill Development:** The Learning Analytics and AI based approaches can be utilised to develop and assess employability skills for example critical thinking, problem-solving, communication and leadership. It facilitates collaboration on group projects

while students learn from the content which is made accessible by the application. The algorithms present the student self-assessment and teacher assessments and places students on a skills assessment framework (from basic to master) for each of the target skills (Also refer to Case Study *Edulai*, Baker & Smith, 2019).

- **Monitoring Student Learning:** Learning Analytics and AI based approaches can be used to create and maintain individual student portfolios that will reflect more evidence-based progress in each subject. In scenarios of remote/ hybrid teaching, these portfolios can assist in forming an informed judgement about students' academic progress and monitoring learning. Furthermore, AI application also acts to support teachers in managing classroom behaviour using an automated seated plan. Moreover, the AI applications aim to save teachers time, supports student monitoring, and reduce workload through data-rich seating plans that reduce behaviour problems (Case Study-Class Charts, Baker & Smith, 2019).

2. Assessment and Feedback

The findings in this study elucidate assessment and feedback as an area of significant concern, following strategies propose incorporating AI to address some of the issues.

- **Diagnostic assessments:** The findings from Study B evidence the key role of diagnostic assessment in accessing prior knowledge of students, scaffolding, mapping the student learning and encouraging self-assessment practices amongst the students. This subsequently encourages more autonomous learning amongst students and help teachers in designing early intervention where needed. The AI application used an adaptive learning platform that identifies student strengths, weaknesses, and gaps in knowledge through diagnostic tests and formative assessment and structures appropriate support and scaffolding (Also refer to Case Study-CENTURY, Baker & Smith, 2019).
- **Formative assessments:** The findings in study A demonstrate significant challenges in the design and delivery of online evidence-based assessments. It also revealed challenges related to conducting assessments and monitoring student learning. The published literature and findings from Study B reveal that AI can be utilised for monitoring learning and ongoing evidence-based formative assessment practices. ALEKS (Craig et al., 2013), OLI learning course (Lovett et al., 2008), SQL-Tutor (Mitrovic & Ohlsson, 1999), Cognitive Tutor (Pane et al., 2014), and ASSISTments (Koedinger et al., 2010) cited in (Luckin & Cukurova, 2019).
- **Feedback:** The findings from Study B and the published literature ALEKS (Craig et al., 2013), OLI learning course (Lovett et al., 2008), SQL-Tutor (Mitrovic, & Ohlsson, 1999), Cognitive Tutor (Pane et al., 2014), and ASSISTments (Koedinger et al., 2010) cited in (Luckin & Cukurova, 2019), and Case Studies (Baker & Smith, 2019) provide insights on immediate and individualised feedback by AI application.
- **Academic Honesty:** Though the application of Learning Analytics and AI in teaching and learning does not directly address the academic honesty aspects, the overview of student learning and diagnostic assessments, individual feedback provide evidence of continuous progress of a student which also helps at every stage in ensuring academic honesty practices. The schools may further develop policies around this feature based on their contexts.

3. Professional Development Strategies

In the context of the school administration apart from automating the mundane administrative tasks which it is known for, learning analytics and AI principles can be utilised to create individual portfolios of the teachers using personal analytics that can assist the school in formulating its professional development plan tailored for its unique context. The school may also consider a similar approach to devise a leadership development plan that offers data-driven tiered support for succession planning at various levels in school (Refer to Case Study DebateMate; Cukurova, Kent, & Luckin, 2019).

The schools may consider designing and developing an AI Readiness training programme to identify and collect data, apply AI approaches, and learn from the outcomes (Also refer to the 7 step ETHICAL AI Readiness framework offers a structure to further support the educational organisations to build AI training (as in Luckin et al., 2022).

4. Strategies to ensure Staff/Student Well Being

Issues related to student and staff well-being emerged as a central concern in this study. Findings from the COVID Research Project and Study A strongly demonstrate an emphasis on the well-being issues which is also concurred by the published literature. AI applications can be utilised to measure the well-being and mood of students and staff and visually represent it. This involves two interfaces: a chat-bot and an emoji-based interface. The chatbot acts as a channel for students and staff to express how they feel about their learning environment, school community and other issues. The emoji-based interface allows students to directly record their feelings by pressing the appropriate emoji button. Subsequently, the collective mood of the school at any given time is reflected on a large screen in the school atrium. This enables the school leadership and staff to make informed judgements about the issues and improve well-being. The data collected from both the interfaces enable the school staff to create collective intelligence, facilitating decision making that considers the views of the stakeholders (Case Study Plymouth School of Creative Arts and Emoti-OS – Towards a collective intelligence, Baker & Smith, 2019).

5. Administrative Strategies

Some of the routine tasks in schools can be managed by AI applications for instance managing learning tasks, sending homework assignments, assessments and communication with parents or other stakeholders. It supports managing administrative tasks in educational contexts that range from sharing of data between schools and colleges to other applications like organising timetables and predicting inspections, use of digital assistants to detect the type of query and redirect it to the most appropriate member of the staff. (Also refer to Case Studies, Baker & Smith, 2019). Moreover, there has been a notable increase in the number of educational settings using online learning platforms to facilitate the delivery of learning tasks, homework, assessments and communication with parents or other stakeholders. Some of these online learning platforms also facilitate tracking or recording student progress (Ferguson, 2012; Tempelaar, Rienties, & Giesbers, 2015).

6. Address issues related to access and Equity

AI presents the potential to address issues related to access and equity in education particularly in scenarios such as the pandemic and in areas where there is a paucity of teachers. AI can offer one-to-one tuition using the Internet and by connecting

students in classrooms with teachers around the world. It can capture a significant amount of data, such as recordings of each tuition session, student assessments, and feedback from students and parents. The machine-learning algorithm facilitates identifying patterns around positive teaching outcomes which can further provide insights on ways to optimise teaching interactions (Also refer to Case study Third Space Learning, Baker & Smith, 2019).

6.2. Proposed Strategies for incorporating emerging technologies in the IB Diploma Programme using Programme Standard and Practices (2020) Framework

Additionally, I have proposed strategies for incorporating emerging technologies like Learning Analytics and AI in the IB Diploma Programme. These are grounded in the literature and based on the findings from Study B. The *Standards and Practices* articulate the foundational set of principles for schools and the IB to ensure quality in the implementation of the IB programmes. The **standards** are general principles that lie at the heart of being an IB World School, while **practices** are further definitions of the standards that include references to implementation (IB, 2020d). I have used some of the standards and associated practices to demonstrate ways in which the emerging technologies may be integrated in the IBDP framework. IB Schools across the globe are in the process of considering a transition to *Programme Standards and Practices 2020* (IB, 2020d) framework, hence these strategies may be further contextualised to serve as guidelines to explore the potential applications of emerging technologies like Learning Analytics and AI to personalise learning experiences, a theme of broad interest and relevance to most formal education providers today.

The next section presents the proposed strategies using *Programme Standards and Practices 2020* framework.

1. Purpose: Sharing an important mission

Standard: Purpose (0101)

Schools implement IB programmes to develop inquiring, knowledgeable and caring young people who help to create a better and more peaceful world through intercultural understanding and respect

Practice: Purpose 1- The governing body and school leaders articulate a purpose for learning that aligns with the IB's philosophy and mission

Purpose 1.1: The school develops a mission, vision and strategy that reflect the IB mission and philosophy

Proposed Strategy: *The governing body and school leaders may articulate a strategy to incorporate AI to promote equity and an inclusive approach to learning in the IBDP, providing information and an understanding of the diverse backgrounds of students which is central to IB philosophy and mission.*

The school may design and develop an AI Readiness training programme to identify and collect data, apply AI approaches, and learn from the outcomes. (Also refer to the 7 step ETHICAL AI Readiness framework offers a structure to further support the educational organisations to build AI training as in Luckin et al., 2022).

2. Environment: Providing essential structures, systems, and resources

Standard: Leadership and governance (0201)

Proposed Strategy: The leadership and governance of IB World Schools create and sustain high-quality learning environments

Practice: Leadership 3-The school organizes time for learning and teaching that provides a broad, balanced and connected curriculum and serves the changing needs of its community.

Leadership 3.1: The school implements a schedule that allows for the requirements of the programme(s) to be met.

DP 1: The school implements and reviews a curriculum that is balanced so that students are provided a reasonable choice of subjects.

DP 2: The school implements a schedule that provides for the minimum required teaching hours for each standard level and higher-level DP subject, and for the theory of knowledge (TOK)

Proposed Strategy: To consider an approach based on Learning Analytics and AI principles in the IBDP, to identify the pattern of concepts and skills, and make informed choices about a range of subjects best suited for DP students.

To incorporate AI in organising timetables and creating individual student schedules in the IBDP (Refer to case study-Class Charts, Baker & Smith, 2019).

Practice: Leadership 4-The school implements and reviews systems and processes to improve the operation and sustainability of its IB programme(s).

Leadership 4.2: The school captures and uses data that informs the operation and sustainability of the programmes(s).

Leadership 4.3: The school captures and uses data that informs the quality of the implementation of the programme(s).

Proposed Strategy: To incorporate an approach based on Learning Analytics and AI principles to identify areas in the IBDP for ongoing development using data sets to make predictions about various aspects including the IBDP student progress and attainment data, school workforce census data, and parental view responses (Refer to Case Study- Targeting school inspections, Baker & Smith, 2019).

Standard: Student support (0202)

Learning environments in IB World Schools support student success.

Practice: Student support 1- The school provides relevant human, natural, built, and virtual resources to implement its IB programme(s).

Student support 1.1: The school provides adequate resources and facilities in accordance with programme documentation

Student support 1.3: The school provides effective learning spaces and learning environments.

Student support 1.5: The school uses programme documentation to inform the use and/or design of learning spaces which allows for flexibility and collaboration

Proposed Strategy: To adopt an approach to incorporate AI for creating effective online learning spaces and learning environments for the IBDP community, particularly during remote/hybrid learning or in areas where access to face-to-face schooling is restricted in scenarios such as the global pandemic (Refer to Century, Edulai, Baker & Smith, 2019).

To adopt an approach to incorporate AI to support teachers in managing classroom behaviour using an automated seated plan. It aims to save teachers time, supports student monitoring, and reduce workload through data-rich seating plans that reduce behaviour problems (Refer to Case Study-Class Charts, Baker & Smith, 2019).

Practice: Student support 2-The school identifies and provides appropriate learning support

Student support 2.1: The school implements and reviews systems and processes to identify the needs of students.

Student support 2.2: The school supports the identified needs of students, and evidences this support through planning, policy, and practice

Proposed Strategy: To adopt measures to incorporate personal analytics of students in teaching and learning in IBDP. The personal analytics supports in identifying the individual needs of students which can further help in continuously reviewing the systems and processes and offering a personalised learning approach in the IBDP.

The published literature suggests some of the widely used Intelligent Tutoring systems for personalised instruction in learning are ALEKS (Craig et al., 2013), OLI learning course (Lovett et al., 2008), SQL-Tutor (Mitrovic & Ohlsson, 1999), Cognitive Tutor (Pane et al., 2014), and ASSISTments (Koedinger et al., 2010) cited in (Luckin & Cukurova, 2019).

Student support 3: The school fosters the social, emotional, and physical well-being of its students and teachers.

Student support 3.1: The school identifies and allocates spaces and resources to support the social, emotional, and physical well-being of its students and teachers.

Student support 3.2: The school demonstrates in its systems, processes, and policies attention to the social, emotional, and physical well-being of its students and teachers.

Student support 3.3: The pedagogical leadership team and teachers support students' social, emotional, and physical well-being

Proposed Strategy: To incorporate measures based on Learning Analytics and AI principles to gain an understanding of learners' and teachers' contexts. These measures include eye-tracking, physical movement and facial recognition for emotion detection widely used across the world (Blikstein, 2013).

The concept of collective intelligence may enable the school leadership and staff to make informed judgements about various school issues and improve well-being. (Refer to Plymouth School of Creative Arts and Emoti-OS –Towards a collective intelligence? (Baker & Smith, 2019).

Standard: Teacher support (0203)

Learning environments in IB World Schools support and empower teachers.

Practice: Teacher support 2-The school ensures that leadership and teachers participate in appropriate and timely professional learning to inform their practice

Teacher support 2.1: The school complies with IB-mandated professional development requirements, as outlined in IB documentation

Proposed Strategy: AI may be utilised in the IBDP to create individual portfolios of the teachers using personal analytics that can assist the school in formulating its professional development plan tailored for its unique context.

For example, Case study DebateMate (see <https://debatebate.com>) focused on personality features and skills for argumentation and debate. This case study is informed by a review of literature from learning science to emphasise on tutor characteristics (Evagorou & Dillon, 2011; Zohar, 2008) specifically, tutors' personal (Klassen & Tze, 2014), emotional (Battistich, Schaps, Watson, Solomon, & Lewis, 2000) and social traits (Lee et al., 2014). Data in this study was collected based on psychometric measures to understand the personality traits and Open SMILE software was deployed to predict the emotional attributes of the tutors (Cukurova, Kent, & Luckin, 2019).

Additionally, the school may design and develop an AI Readiness training programme to identify and collect data, apply AI approaches, and learn from the outcomes. (Also refer to the 7 step ETHICAL AI Readiness framework offers a structure to further support the educational organisations to build AI training as in Luckin et al., 2022).

3. Culture: Creating positive school cultures

Standard: Culture through policy implementation (0301)

Schools develop, implement, communicate, and review effective policies that help to create a school culture in which IB philosophy can thrive.

Practice: Culture 5: The school implements, communicates, and regularly reviews an assessment policy or policies to help create a culture of continuous learning and growth.

Culture 5.4: The school ensures relevant support materials, resources and processes are implemented for fair and valid assessment

Proposed Strategy: To adopt learning analytics and data driven approaches in regularly analysing and reviewing students' performance data and creating processes for fair and valid assessments (Ferguson, 2012; Tempelaar, Rienties, & Giesbers, 2015).

(Also refer to the 7 step ETHICAL AI Readiness framework offers a structure to further support the educational organisations to build AI training as in Luckin et al., 2022).

4.Learning: Ensuring effective education

Standard: Designing a coherent curriculum (0401)

Learning in IB World Schools is based on a coherent curriculum

Practice: Coherent curriculum 1- The school plans and implements a coherent curriculum that organizes learning and teaching within and across the years of its IB programme(s)

Coherent curriculum 1.5: The school articulates its schedule and curriculum to make it possible for students to make connections across their learning.

Coherent curriculum 1.6: The school demonstrates that the curriculum is influenced by an understanding of students' prior knowledge, identities, backgrounds, needs and contexts.

Proposed Strategy To incorporate diagnostic assessment practices across DP subjects using Learning analytics and AI principles which may help in accessing prior knowledge, mapping student learning, and encouraging self-assessment practices amongst the students.

Standard: Students as lifelong learners

Learning in IB schools aims to develop students ready for further education and life beyond the classroom

Practice: Lifelong learners 1- Students actively develop thinking, research, communication, social and self-management skills.

Lifelong learners 1.1: The school implements and reviews the development of the IB's approaches to learning.

Lifelong learners 1.2: The school implements and reviews processes that actively engage students in their own learning.

Proposed Strategy: The adaptive learning approach offered by Learning Analytics and AI identifies student strengths, weaknesses, and gaps in knowledge through diagnostic tests and formative assessment and structures appropriate support and scaffolding. Students will derive benefits from this personalised support that includes individual tiered support, additional practice, self-paced learning, and revision assistance.

Lifelong learners 3-Students identify and foster healthy relationships, an understanding of shared responsibility, and the ability to collaborate effectively

Lifelong learners 3.1: Students and teachers engage in learning experiences that are designed to include opportunities for students to collaborate

Proposed Strategy: To implement Learning Analytics and AI based approaches in developing collaborative practices in teaching and learning that provide opportunities for IBDP students to engage in varied learning experiences both individually and in a group. For example, using a Collaborative Problem Solving (CPS) approach in curriculum planning both for students and teachers (Spikol, Ruffaldi, Dabisias, & Cukurova, 2018). Refer to Case Study PELARS (<http://www.pelars.eu>).

Practice: Lifelong learners 6- Students take ownership of their learning by setting challenging goals and pursuing personal inquiries.

Lifelong learners 6.1: Students take opportunities to develop personal learning goals.

Lifelong learners 6.2: Students take opportunities to ask questions and pursue personal inquiries and actions.

Proposed Strategy: The findings from Study B and the published literature encapsulates the learner model of AI enables interactions between the learner and computer/machines. These interactions include information regarding learners' achievements, attributes, emotional state, current academic activities and how they are implementing the feedback in their learning. This personal analytics offers an individual learning path personalising the learning experience for each student. It will enable IBDP students to co-design their learning activities, engage on an individual basis, and take ownership of their learning. CENTURY Tech, Cognii, iReady, Edmentum, Cog Books, and Summit Learning are some applications offering this support.

Standard: Approaches to teaching (0403)

IB programmes encourage approaches to teaching that create learning experiences that are shown to be meaningful to the school community.

Practice: Approaches to teaching 1- Teachers use inquiry, action, and reflection to develop natural curiosity in students.

Approaches to teaching 1.1: Teachers use inquiry-based teaching strategies and learning engagements

Approaches to teaching 1.2: The school monitors and evaluates inquiry-based teaching strategies and learning engagements.

Approaches to teaching 1.3: The school provides opportunities for students to actively engage in interactive and exploratory learning environments and/or play in accordance with programme documentation.

Approaches to teaching 1.4: Teachers encourage student choice in appropriate places in the curriculum.

Approaches to teaching 1.5: Teachers facilitate student exploration of their personal interests and ideas.

Proposed Strategy: AI and Learning Analytics approaches enable identifying strengths, weaknesses, and gaps in knowledge to facilitate scaffolding and provide more personalisation in learning. These provisions are particularly helpful to facilitate flipped learning where the intelligent tutoring system may be used to gain new conceptual understanding and classroom contact time may be used to further the understanding of these concepts. This may be used for IBDP students to develop self-paced active engagement, a self-learning, self-assessing behaviour which facilitates lifelong learning.

Furthermore, this feature will enable IBDP learners in engaging in the curriculum delivery and help in identifying topics of their choice based on their personal strengths and weaknesses. This includes a selection of subjects, IA tasks, EE topics and formative assessment tasks in the IBDP. Some examples include Century Tech, Edmentum, and Cognii that actively engage and support an exploratory learning environment.

Standard: Approaches to assessment (0404)

Learning, teaching, and assessment effectively inform and influence one another.

Practice: Approaches to assessment 1- Students and teachers use feedback to improve learning, teaching, and assessment

Approaches to assessment 1.2: The school uses specific and constructive school-based reporting to provide students and teachers with information that can be used to improve learning, teaching, and assessment

Proposed Strategy: AI may support in offering ongoing feedback on the learning activities of IBDP students which will keep the teachers suitably informed and help in using this information to scaffold learning activities, plan the unit of teaching and implement differentiation effectively. (Also refer to MATHIA, CENTURY Tech, Cognii, iReady, Edmentum, Cog Books, and Summit Learning).

Practice: Approaches to assessment 2- The school uses assessment methods that are varied and fit-for-purpose for the curriculum and stated learning outcomes and objectives

Approaches to assessment 2.1: Teachers use a variety of assessment methods that are connected to stated learning objectives and outcomes.

DP 1: The school uses the objectives and assessment tools for each subject, and component of the DP core, to build summative assessments of student learning.

Proposed Strategy: AI may be suitably employed to assist IBDP students in a structured, self-paced and individualised manner based on the data obtained from their personal analytics. The teachers may use the AI application for guiding and internal marking of essays to build summative assessments of student learning.

Practice: Approaches to assessment 4-Students take opportunities to consolidate their learning through assessment

Approaches to assessment 4.1: The school provides students with opportunities to consolidate their learning through a variety of assessments.

DP 1: The school ensures that students submit the extended essay toward the end of the DP, and focuses on providing students with opportunities to engage in topics of their own choice

Proposed Strategy: Learning Analytics and AI application can offer an individual learning path for IBDP students based on their diagnostic assessment that will include a variety of additional learning tasks, revision worksheets and formative assessments. The student is given the opportunity to accomplish this at their own pace.

The diagnostic assessment and personal analytics of students may be utilised in the IBDP to provide students with opportunities to engage in topics of their own choice. Additionally, the published literature reflects Artificial Intelligence in Education (AIEd) is positioned to transform the assessment process in future. Those are discussed below.

The automated marking and AI-based assessment tools can effectively address teachers' excessive workload that affects wellbeing, retention, and recruitment.

Secondly, AI-based adaptive learning platforms provide the opportunity to personalise instruction and address a longstanding issue in education is about the 'One-size-fits-all' learning approach with inflexible learning pathways

Thirdly, the challenges associated with the narrow assessment constrain teaching and learning which also reduces the innovation capacity of experienced and highly trained teachers. AI appears promising in this area as it offers added opportunities for formative assessments and a wider range of skills and aptitudes to be tested.

In view of the aforesaid, Learning Analytics and AI principles may be incorporated into the IBDP to create and maintain individual student portfolios that will reflect more evidence-based progress in each subject. In scenarios of remote/ hybrid teaching, these portfolios may assist in forming informed judgement about students' academic progress and monitoring learning. Matters related to formative assessments and predicted grades in the IBDP may be addressed with a data-driven approach by the schools should they adopt this approach. The school may design and develop an AI Readiness training programme to identify and collect data, apply AI approaches, and learn from the outcomes. Furthermore, the 7 step ETHICAL AI Readiness framework offers a structure to further support the educational organisations to build AI training (as in Luckin et al., 2022).

6.3. Closing remarks

The results of this research further our understanding on several key issues in relation to pedagogy, assessment, learning environments and experiences of students and teachers during a period of enormous change arising due to the global pandemic. It provides an insight on several significant concerns in relation to the implementation of the online teaching and learning and the use of digital technology during the pandemic. This study captures IBDP teachers/coordinators rich descriptions of the specific transitioning experiences to online teaching due to the global pandemic which will pave way for further investigation into the issues arising from this research.

Likewise, the findings from this research present early outcomes that have recognised the potential of emerging digital technologies in teaching and learning, including its current limitations. The burgeoning area of AI and learning analytics offer an encouraging opportunity for further research to understand its implications on teaching and learning in the context of IB Diploma Programme in future.

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Appendices

Appendix A: Online Survey

Study A Research Project-IBDP Teachers/Coordinators

IBDP Teachers/ Coordinators Survey

My name is Naaz Kirmani. I am a doctoral researcher in the Department of Education at the University of Bath, working with Professor Mary Hayden and Professor Jeff Thompson as my supervisors. My research, which has been given ethical approval by the University of Bath, is an exploration of the impact of Technology-Enhanced Learning (TEL) on pedagogy, assessment and learning environments in schools worldwide. The term Technology-Enhanced Learning (TEL) refers to the potential, application and implications of technologies, especially digital technologies, in educational contexts such as schools, professional training environments, and online learning. Digital technology in teaching and learning includes the use of electronic tools, systems, devices, and resources that generate, store or process data. Some of the popular examples include use of social media, online games, multimedia, and mobile phones.

COVID-19 pandemic recently has caused a major shift to online teaching and learning across the globe. This survey aims to analyse the perspectives of the IB Diploma teachers on the use of digital technology in teaching and learning. It investigates ways in which this shift to online teaching in response to COVID -19 pandemic has impacted their pedagogical approaches. I hope you will be willing to support this project by completing this survey which should take no more than 15-20 minutes to complete. Participation in this project is completely voluntary, and you can be assured that all your responses will be treated as confidential. You may, at any time decide to withdraw from the interview process or request that any data you have provided is withdrawn from the data analysis process within two weeks of participation.

1. Background Information

a) Please select which of the following applies to you
You may select multiple options from the drop-down menu

IBDP Teacher
IBDP Coordinator
Other

b) Please indicate your teaching subject in the IBDP here:

c) Please indicate the element of the DP Core (if any) that you facilitate.

- Theory of Knowledge
- CAS
- Extended Essay
- None of the above

d) Please indicate your school location (country) here:

e) Please indicate if your school is currently offering: (please select just one option)

- Completely face to face teaching
- Completely online teaching
- A mixture of face to face and online teaching

2. Learning Environment

This section explores the significant elements related to digital learning environment including the physical environment, technical support, digital tools, and resources to support teaching in response to COVID-19 pandemic.

Please indicate the extent of your agreement with the following statements.

The school in which I am currently teaching offers:	Strongly Agree	Agree	Disagree	Strongly Disagree
1. a supportive organisational culture for innovation in teaching and learning				
2. a reliable digital infrastructure to support teaching and learning				
3. a set of clear safety protocols for the use of digital technology in teaching and learning				
4. access to a wide range of digital resources				
5. support for networking opportunities using digital technology within my subject and beyond				
6. opportunities for collaboration using digital technology within my subject and beyond				
7. support for group work using technology within my subject and beyond				
8. continuous up-skilling opportunities to use digital technology within my subject and beyond				
9. opportunities for personalized learning experiences for learners				
10. opportunities to teachers to engage learners as active participants in the digital learning process				
11. opportunities for learners to be self-directed through flexible curricular choices				

b) Please indicate which of the following technology tools you have used in teaching during the online teaching in response to COVID-19 pandemic:

(You may select multiple options from the drop-down menu)

- Learning Management Software
- Presentation Software
- Smartboard
- Tablets
- Mobile Device
- E books
- Podcasts
- Moodle
- Zoom
- Google Docs
- Notetaking and Evernote
- Microsoft Office 365 tools for teaching
- Social Media Platform
- Online Games
- Digital Field trips
- Augmented Reality (AR) Model
- Virtual Reality (VR) Model
- OERs (Open Educational Resources)
- Audio feedback software
- Apple Teacher
- Artificial Intelligence learning platform
- Other

c) Please add any other option here:

d) Please comment on a specific personal challenge (if any) that you have experienced in relation to school support and digital infrastructure that has impacted your teaching in responding to the COVID-19 pandemic

3. Curriculum & Pedagogy

This section explores the effects of digital technology on teaching approaches in response to COVID-19 pandemic.

Please indicate the extent of your agreement with the following statements

Using digital technology in teaching has enabled me to:	Strongly Agree	Agree	Disagree	Strongly Disagree
1.deliver the content in my subject with confidence				
2.incorporate inquiry-based approaches effectively				
3.integrate complex concepts in a creative manner				
4.use a range of teaching strategies to improve learners engagement				
5.incorporate online tools that enable learners to access content and learn at their own pace				
6.integrate real-life connections within my subject and beyond				
7. design learning tasks focused on individual learning abilities of learners				
8.create collaborative learning opportunities within my subject and beyond				
9.provide individualized support to learners with varying learning needs				
10.differentiate tasks based on content and skill				
11.develop skills consistent with internal assessment tasks				
12.focus on research skills consistent with Extended Essay requirements				
13.enhance my relationship with learners through ongoing interaction and dialogue around the learning process				

b) In your opinion, which aspects of your teaching in the IBDP need pedagogic support to incorporate digital technology effectively? Please include brief notes here

c) Please comment on a specific personal challenge (if any) that you have experienced in incorporating digital technology in your subject in the IBDP in response to COVID-19 pandemic.

4. Assessment and Feedback

The section explores the effects of digital technology in relation to assessment design, delivery, and support to student learning in response to COVID-19 pandemic.

Please indicate the extent of your agreement with the following statements

The application of digital technology in conducting assessment and providing feedback has enabled me to	Strongly Agree	Agree	Disagree	Strongly Disagree
1.explain learning objectives and goals efficiently, using online interaction				
2.implement interactive assessments in my subject				
3.respond to learners' conceptual difficulties effectively				
4.incorporate online tools that enables learners to self-assess their work				
5. provide learners with a choice of topics, methods, criteria, and timings of assessments in my subject				
6. conduct pre-assessment in a variety of ways for building on learners' prior knowledge				
7.incorporate variety in the design of assessments for example interactive online tests that facilitates learner-led formative assessment				
8.capture wider skills not easily assessed by other means				
9.monitor individual learner progress efficiently over time				
10.provide effective, immediate, and individualised feedback				
11.improve learner engagement with ongoing feedback process				
12.ensure valid results with opportunities to combine human and computer marking				
13.implement efficient submission, marking, moderation and data storage in my subject				
14. use assessment process to inform and align my teaching practices				

b) Please indicate which of the following you have used in assessing digitally:

(You may select multiple options from the drop-down menu)

Individual Assignments

Essays

E-portfolios

Self-Assessment

Peer Assessment

Group project

Online quizzes

Online presentations

Online learning logs

Open book assignment

Multiple Choice questions

Journals/blogs

Lab Reports

Posters

Reflections

Other

c) Please comment on challenges (if any) you have experienced in using digital technology in relation to design assessments in your subject in the IBDP in response to COVID-19 pandemic

d) Please comment on challenges (if any) you have experienced in using digital technology while conducting assessments in your subject in the IBDP in response to COVID-19 pandemic.

e) If you would like to add any additional comment, please do so in the box below:

f) Lastly, if you would be willing to be contacted again for a follow-up interview as part of this study, please provide your name and email address below. (These details will not be used for any other purpose, and any communication will be completely confidential).

Thank you for taking time to complete this survey. In order for your views to be taken into account in our analysis, the survey should be completed by no later than **18 May 2021**

Appendix A1: Interview Guide

Study A Research Project (IBDP Teachers/Coordinators)

Interview Questions-IBDP Teachers/Coordinators

1. In what ways has the use of digital technology impacted your teaching approaches in response to the COVID-19 pandemic?

- a) In what ways do you think it influenced the content delivery in your subject?
- b) How did you address it?

2. In what ways has the use of digital technology addressed the differentiated/personalized needs of the learners in your subject?

- a) What steps did you take to ensure that student learning reflect their individual ability and potential?
- b) What (if at all) could have been done differently?

3. In what ways has the use of digital technology provided autonomous learning opportunities for students in your subject?

4. In what ways has the use of digital technology influenced the assessment practices in your subject?

- a) In your opinion, what aspects of online assessments need distinct focus in the IBDP?

5. What steps did you take to monitor student learning in a digital learning environment?

- a) Do you have school wide practices in place to address the issues related to Academic Honesty.

6. In view of the use of digital technology, what aspects of professional development should now be focused in your school setting?

- a) From your experience of online teaching, how do you envision the use of digital technology in your subject in future?
- b) What support do you need to incorporate this?

Appendix B: Student Online Survey

Study B-Case Study

My name is Naaz Kirmani, and I am a doctoral researcher in the Department of Education at the University of Bath working with Professor Mary Hayden and Professor Jeff Thompson as my supervisors. This research study focuses on the role of Artificial Intelligence in the development of autonomous learning skills with an emphasis on formative assessment strategies as an important aspect of learning in the 21st century.

This survey aims to gather your perspectives on the use of Artificial Intelligence application in mathematics. I hope you will be willing to support this project by completing this survey which should take no more than 15 minutes to complete. Participation in this project is completely voluntary, and you can be assured that all your responses will be treated as confidential. You may, at any time, decide to withdraw from the study or request that any data you have provided is withdrawn from the data analysis process.

1. Background Information

a) Please select which Grade you are currently in:

1. Grade 9
2. Grade 11

b) Please indicate if in your Grade your school is currently offering: (please select just one option)

- Completely face-to-face teaching
- Completely online teaching
- A mixture of face-to-face and online teaching

c) Please indicate how you use the Artificial Intelligence application in learning: (multiple option)

- Individually
- Group work
- Other (please specify in the box below)

d) Please indicate how often you use the Artificial Intelligence application:

- Every day
- Twice a week
- Once a week
- Fortnightly
- Once a month
- Other (please specify in the box below)

e) Please indicate if you feel the Artificial Intelligence application provides you with individual support:

- Yes
- No
- Not Sure
- Other (please specify in the box below)

f) Please indicate which of the following technology tools you use in accessing the Artificial Intelligence application:

- Computer
- Laptop
- Tablet
- I-pad
- Smartphone
- Other (please specify in the box below)

2. Learning Environment

This section explores significant elements related to the learning environment including the physical environment, technical and resource support, Artificial Intelligence application used to support learning.

Please indicate the extent of your agreement with the following statements.

The Artificial Intelligence application that my school offers provides:	Strongly Agree	Agree	Disagree	Strongly Disagree
1. clear instructions related to learning activities				
2. full technical support				
3. a wide range of learning resources				
4. easy access to learning modules				
5. well-designed learning tasks				
6. help with organising learning independently				
7. self-paced learning opportunities				
8. opportunities for increased engagement in the learning task				
9. opportunities for learners to be self-directed through individual learning paths				
10. opportunities for personalised learning experience				
11. collaborative learning opportunities with my peers				

a) Please comment on specific personal benefits (if any) that you have experienced in relation to the use of Artificial Intelligence in learning.

b) Please comment on specific personal challenges (if any) that you have experienced in relation to the use of Artificial Intelligence in learning.

3. Curriculum & Pedagogy

This section explores the impact of Artificial Intelligence on various approaches to learning.

Please indicate the extent of your agreement with the following statements

The use of Artificial Intelligence in learning has enabled me to:	Strongly Agree	Agree	Disagree	Strongly Disagree
1. understand the math content with confidence				
2. set personal learning goals				
3. remain curious to learn new concepts				
4. understand complex concepts through practice				
5. actively engage in the learning process				
6. practise on a range of topics at my own pace				
7. access content focused on my individual learning abilities				
8. access learning tasks based on my individual skills				
9. integrate real-life connections within my subject				
10. continuously practise the concepts taught in class				

a) Please comment on the quality of the content and learning tasks offered by the Artificial Intelligence application.

b) Please comment on specific ways in which the Artificial Intelligence application supported your individual learning needs.

c) Please comment on specific ways in which the Artificial Intelligence application helped you to improve your self-management skills.

4. Assessment and Feedback

The section explores the impact of Artificial Intelligence in relation to assessment, feedback, and support for student learning.

Please indicate the extent of your agreement with the following statements

The use of Artificial Intelligence for assessment and feedback has enabled me to:	Strongly Agree	Agree	Disagree	Strongly Disagree
1. understand my specific strengths in math				
2. understand my specific weaknesses in math				
3. continuously self-monitor my learning				
4. have a choice of topics, methods, criteria, and timings of assessments in my subject				
5. receive effective feedback				
6. receive immediate feedback				
7. receive individualised feedback				
8. continuously reflect on the feedback				
9. revise or review weak areas of learning				
10. engage in self-assessing my work				
11. gain a wider range of math skills				
12. increase my self-confidence, being in charge of my learning				

a) Please comment on the quality and effectiveness of feedback in your experience while using the Artificial Intelligence application in learning.

b) Please comment on ways in which using the Artificial Intelligence application enhanced your performance in formative assessments in mathematics.

c) Lastly, please comment on how the use of the Artificial Intelligence application improved your overall learning outcomes in mathematics.

d) If you would like to add any additional comments, please do so here:

Thank you for taking time to complete this survey.

Appendix B1: Interview Guide

Study B (Case Study)

Interview questions with the students at School

1) In what ways has the use of xxxxx supported you to plan your learning independently in mathematics?

a) How far did it help in improving your overall self-management skills?

2) In what ways the learning path offered by the xxxxx provided you with individual support in mathematics?

3) In what ways the feedback process offered by the xxxxx supported your learning?

4) In what ways the learning activities provided by the xxxxx complemented your course content in mathematics?

5) How far the learning activities offered by the xxxxxx prepared you for the ongoing assessments in the classroom?

a) In what ways has the use of xxxxx enhanced your overall performance in mathematics?

6) In what ways has the use of xxxxx helped you to gain more confidence about your learning in mathematics?

7) Finally, is there anything connected with the use of xxxxx which has not been discussed, that you feel strongly about and would like to bring up now?

Appendix B2: Interview Guide

Study B (Case Study)

Interview Questions (with the Mathematics Teacher)

- 1) In what ways has the xxxxx supported your teaching practices in mathematics?
- 2) What are the key areas that have reflected positive outcomes in teaching and learning of mathematics with the implementation of xxxxx?
- 3) How has the xxxxx helped in addressing the personalized learning needs of the students in mathematics?
- 4) In your opinion, how has the xxxxx improved the autonomous learning skills of the students?
- 5) In what ways has the use of xxxxx supported the ongoing assessment process in mathematics?
 - a) What role has the diagnostic assessment played in scaffolding learning in mathematics?
 - b) What if at all can be done more to support assessment process while using the xxxxx?
- 6) In what ways the feedback provided by the xxxxxx supported student learning?
 - a) How if at all, it could have been differently in this area?
- 7) In what ways could you monitor student learning while using the xxxxx?
Please provide examples.
- 8) What are the specific challenges that you have experienced in the implementation of xxxxx in your school?
- 9) Now with your first-hand experience of using xxxxx and looking at the present context of learning, the way things are moving towards digital technology, in your view what are the implications of implementing artificial intelligence in schools in future?

Appendix C: Quantitative Findings

Study A

Table 1: Responses from survey question 2

Survey Question No.	Question	Strongly Agree (%)	Agree (%)	Disagree (%)	Strongly Disagree (%)
2.1	a supportive organisational culture for innovation in teaching and learning	49.4	46.8	2.5	1.3
2.2	a reliable digital infrastructure to support teaching and learning	46.8	51.9	0.0	1.3
2.3	a set of clear safety protocols for the use of digital technology in teaching and learning	45.6	53.2	0.0	1.3
2.4	access to a wide range of digital resources	36.7	51.9	10.1	1.3
2.5	support for networking opportunities using digital technology within my subject and beyond	34.2	55.7	7.6	2.5
2.6	opportunities for collaboration using digital technology within my subject and beyond	35.4	54.4	6.3	3.8
2.7	support for group work using technology within my subject and beyond	36.7	49.4	10.1	3.8
2.8	continuous up-skilling opportunities to use digital technology within my subject and beyond	36.7	46.8	13.9	2.5
2.9	opportunities for personalised learning experiences for learners	28.2	61.5	7.7	2.6
2.10	opportunities for teachers to engage learners as active participants in the digital learning process	32.1	57.7	7.7	2.6
2.11	opportunities for learners to be self-directed through flexible curricular choices	33.3	47.4	14.1	5.1

Table 2: Range of technology tools from Survey question 2. a.

Name of the technology tool	Response received (%)
Learning Management Software	34.2
Presentation Software	60.8
Smartboard	36.7
Tablets	46.8
Mobile Device	58.2
E books	74.7
Podcasts	35.4
Moodle	12.7
Zoom	83.5
Google Docs	77.2
Notetaking and Evernote	22.8
Microsoft Office 365 tools for teaching	59.5
Social Media Platforms	31.6
Online Games	46.8
Digital Field trips	12.7
Augmented Reality (AR) Model	5.1
Virtual Reality (VR) Model	8.9
OERs (Open Educational Resources)	11.4
Audio feedback software	17.7
Apple Teacher	5.1
Artificial Intelligence learning platform	1.3
Other	12.7

Table 3: Summary of the responses from survey question 3

Survey Question No.	Question	Strongly Agree (%)	Agree (%)	Disagree (%)	Strongly Disagree (%)
3.1	deliver the content in my subject with confidence	48.1	49.4	2.5	0.0
3.2	incorporate inquiry-based approaches effectively	26.6	62.0	11.4	0.0
3.3	integrate complex concepts in a creative manner	31.6	59.5	8.9	0.0
3.4	use a range of teaching strategies to improve learners' engagement	44.3	46.8	8.9	0.0
3.5	incorporate online tools that enable learners to access content and learn at their own pace	46.2	50.0	2.6	1.3
3.6	integrate real-life connections within my subject and beyond	40.5	49.4	8.9	1.3
3.7	design learning tasks focused on individual learning abilities of learners	42.3	47.4	10.3	0.0
3.8	create collaborative learning opportunities within my subject and beyond	37.2	55.1	7.7	0.0
3.9	provide individualised support to learners with varying learning needs	35.4	53.2	11.4	0.0
3.10	differentiate tasks based on content and skill	31.6	51.9	16.5	0.0
3.11	develop skills consistent with internal assessment tasks	36.7	54.4	8.9	0.0
3.12	focus on research skills consistent with Extended Essay	36.2	56.5	7.2	0.0
3.13	enhance my relationship with learners through ongoing interaction and dialogue around the learning process	36.7	49.4	13.9	0.0

Table 4: Responses from survey question 4

Survey Question No.	Question	Strongly Agree (%)	Agree (%)	Disagree (%)	Strongly Disagree (%)
4.1	explain learning objectives and goals efficiently, using online interaction	36.7	59.5	3.8	0.0
4.2	implement interactive assessments in my subject	29.1	62.0	8.9	0.0
4.3	respond to learners' conceptual difficulties effectively	26.9	57.7	15.4	0.0
4.4	incorporate online tools that enable learners to self-assess their work	29.1	60.8	10.1	0.0
4.5	provide learners with a choice of topics, methods, criteria, and timings of assessments in my subject	26.6	59.5	12.7	1.3
4.6	conduct pre-assessment in a variety of ways for building on learners' prior knowledge	31.6	58.2	10.1	0.0
4.7	incorporate variety in the design of assessments, for example, interactive online tests that facilitate learner-led formative assessment	35.4	49.4	13.9	1.3
4.8	capture wider skills not easily assessed by other means	20.3	49.4	29.1	1.3
4.9	monitor individual learner progress efficiently over time	24.4	62.8	11.5	1.3
4.10	provide effective, immediate, and individualised feedback	34.2	55.7	10.1	0.0
4.11	improve learner engagement with an ongoing feedback process	29.1	59.5	11.4	0.0
4.12	ensure valid results with opportunities to combine human and computer marking	28.2	53.8	16.7	1.3
4.13	implement efficient submission, marking, moderation and data storage in my subject	31.6	58.2	8.9	1.3
4.14	use an assessment process to inform and align my teaching practices	30.4	60.8	7.6	1.3

Table 5: Range of assessment task from Survey question 4. a.

SL.No.	Assessment Tasks (Used for digital assessments)	Response received (%)
1.	Individual Assignments	86.1
2.	E-Portfolios	39.2
3.	Self-Assessment	70.9
4.	Peer Assessment	58.2
5.	Group Project	57
6.	Online Quizzes	74.7
7.	Online Presentations	73.4
8.	Online Learning Logs	8.9
9.	Open Book Assignment	27.8
10.	Multiple Choice Questions	63.3
11.	Journals/Blogs	31.6
12.	Lab Reports	32.9
13.	Posters	34.2
14.	Reflections	74.7
15.	Essays	58.2
16.	Other	7.6

Table 6: Responses from survey question 2

Survey Question No.	Question	Strongly Agree (%)	Agree (%)	Disagree (%)	Strongly Disagree (%)
2.9	opportunities for personalised learning experiences for learners	28.2	61.5	7.7	2.6
2.11	opportunities for learners to be self-directed through flexible curricular choices	33.3	47.4	14.1	5.1
3.5	incorporate online tools that enable learners to access content and learn at their own pace	46.2	50.0	2.6	1.3
3.7	design learning tasks focused on individual learning abilities of learners	42.3	47.4	10.3	0.0
3.9	provide individualised support to learners with varying learning needs	35.4	53.2	11.4	0.0
4.4	incorporate online tools that enable learners to self-assess their work	29.1	60.8	10.1	0.0
4.7	incorporate variety in the design of assessments, for example, interactive online tests that facilitate learner-led formative assessment	35.4	49.4	13.9	1.3

Appendix C1: Quantitative Findings

Study B

Table 7: Presents the elements related to learning environment

The Artificial Intelligence (AI) application that the school offers provides:	Strongly Agree	Agree	Disagree	Strongly Disagree
1. Clear instructions related to learning activities	3	3		
2. Full technical support	2	3	1	
3. A wide range of learning resources	2	4		
4. Easy access to learning modules	2	3	1	
5. Well- designed learning tasks	2	4		
6. Help to organise learning independently	2	3		1
7. Self-paced learning opportunities	2	3		1
8. Opportunities for increased engagement in the learning task		6		
9. Opportunities for learners to be self-directed through individual learning path	1	5		
10. Opportunities for personalised learning experience	1	5		
11. Collaborative learning opportunities with my peers		4	2	

Table 8: The impact of AI on various approaches to learning

The use of Artificial Intelligence (AI) in learning has enabled students to:	Strongly Agree	Agree	Disagree	Strongly Disagree
1. Understand the subject specific content with confidence	2	4		
2. Set personal learning goals	1	2	3	
3. Remain curious to learn new concepts	1	4	1	
4. Understand complex concepts through practice	2	4		
5. Actively engage in the learning process	2	4		
6. Practice on a range of topics at my own pace	1	5		
7. Access content focused on my individual learning abilities	2	4		
8. Access learning tasks based on my individual skills	3	3		
9. Integrate real-life connections within my subject	1	4		1
10. Continuously practice the concepts taught in the class	2	4		

Table 9: The impact of AI on assessment and feedback

The use of Artificial Intelligence (AI) for assessment and feedback has enabled students to:	Strongly Agree	Agree	Disagree	Strongly Disagree
1. Understand my subject specific strengths	3	3		
2. Understand my subject specific weaknesses	3	3		
3. Continuously self-monitor my learning		5	1	
4. Have a choice of topics, methods, criteria, and timings of assessments in my subject		5	1	
5. Receive effective feedback	2	2	2	
6. Receive immediate feedback	2	2	2	
7. Receive individualised feedback	2	2	2	
8. Continuously reflect on the feedback	1	5		
9. Revise or review weak areas of learning	1	5		
10. Engage in self-assessing my work	2	4		
11. Gain a wider range of subject specific skills	3	3		
12. Increase my self-confidence	2	4		
13. Being in-charge of my learning	3	3		